ME and Amino Acid Requirements of Broiler Breeders

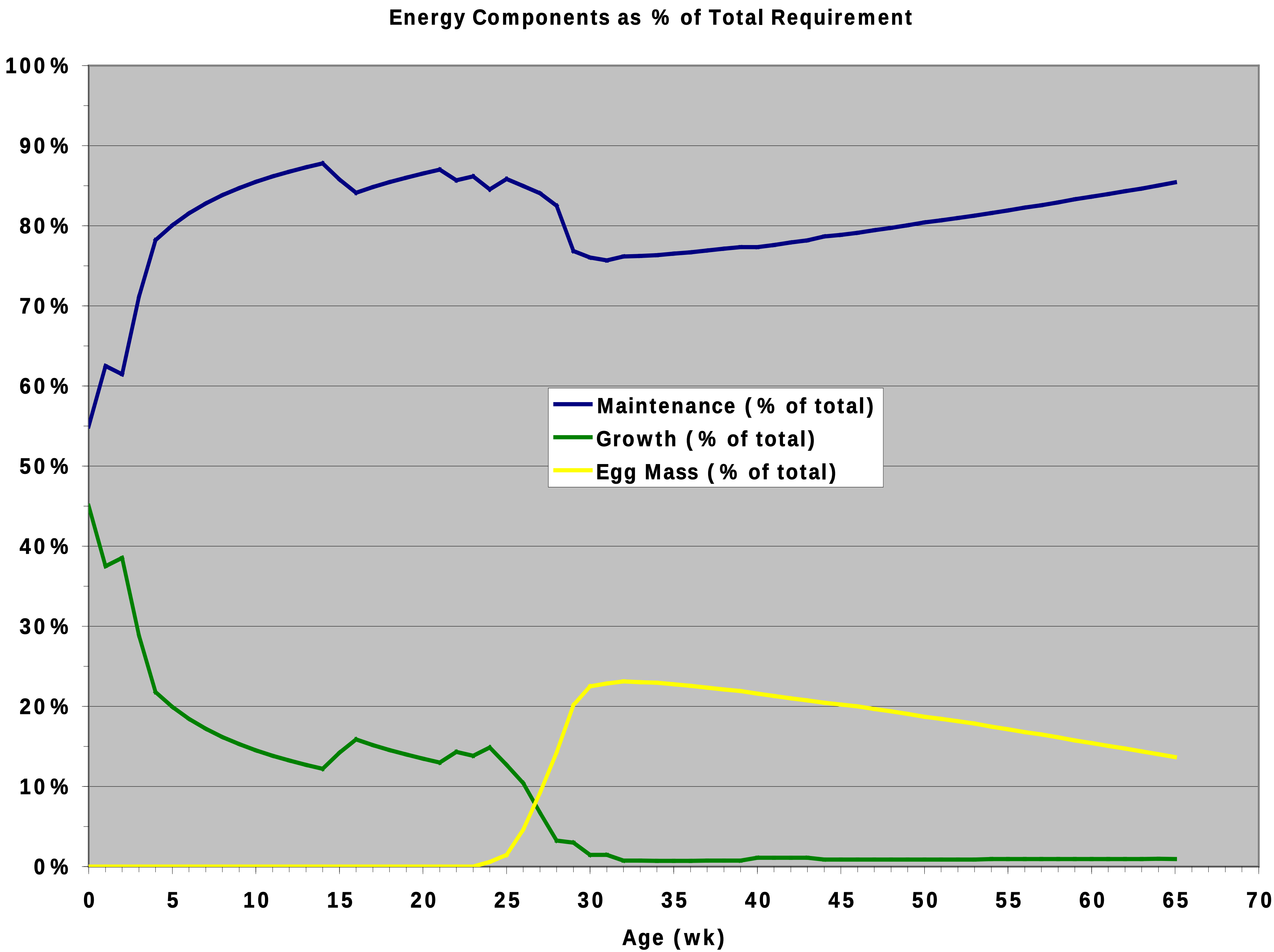
Ceylan Intercontinental Hotel

March 29-30, 2010

ASAIM/USB

Craig Coon

University of Arkansas


Energy Components as % of Total Requirement
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Age (wk)
Maintenance (% of total)
Growth (% of total)
Egg Mass (% of total)

Broiler Breeder Hen

Metabolizable Energy Requirements for Maintenance, Body Weight Gain and Egg Production

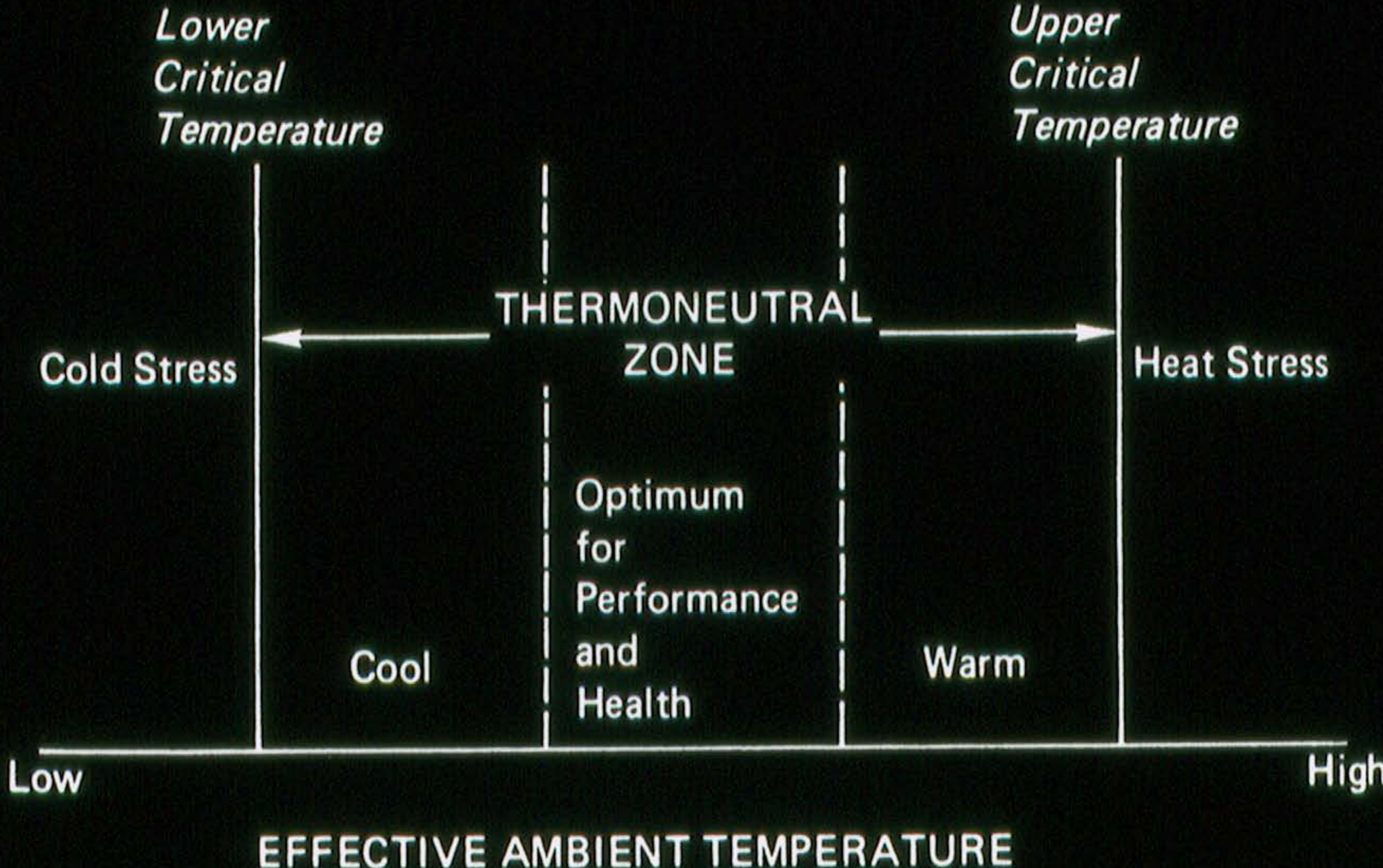


FIGURE 1. Schematic representation showing relationship of thermal zones and temperatures.

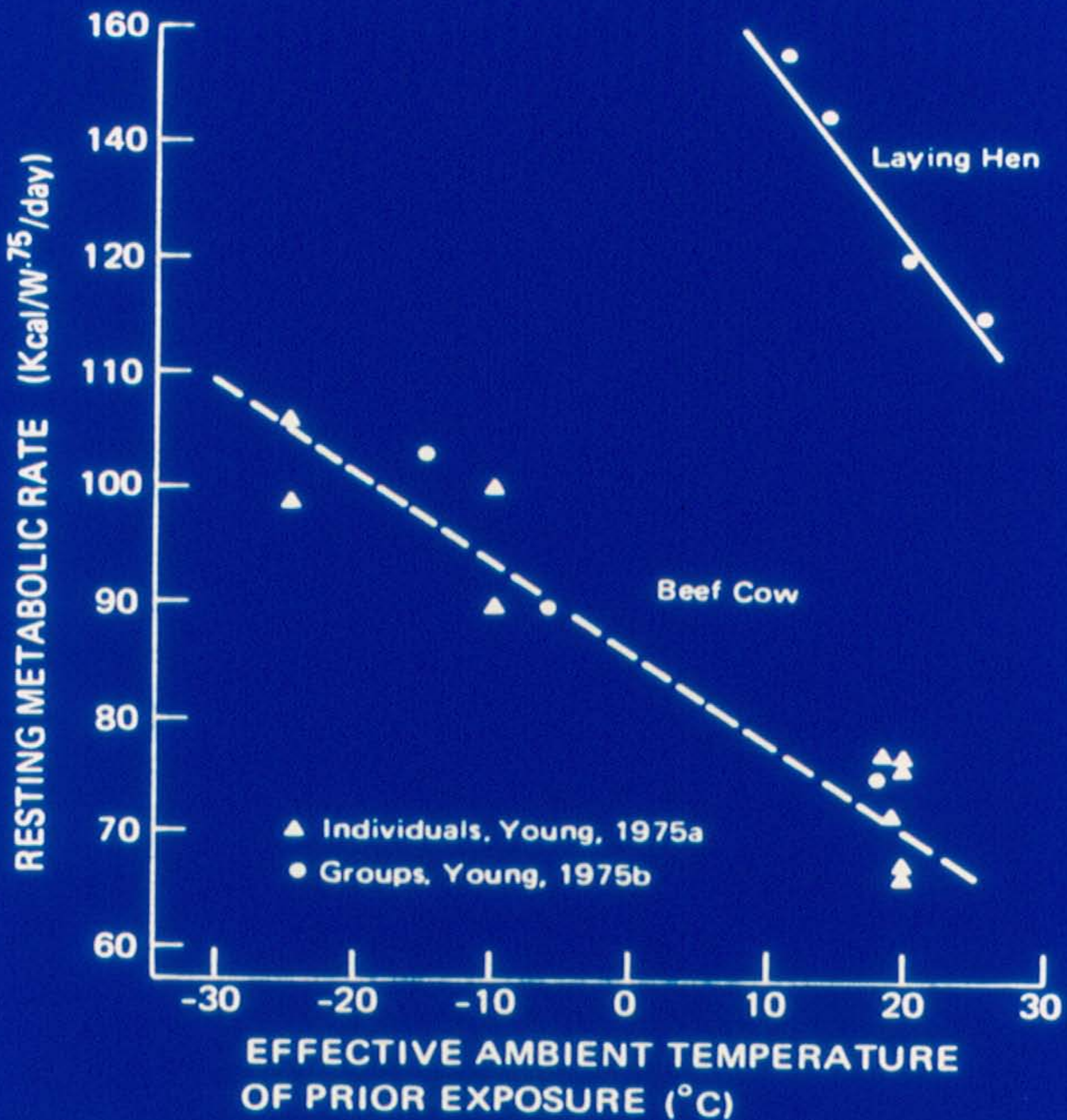


FIGURE 4. Basal metabolic heat production for laying fowl (van Kampen and Romijn, 1970) and resting metabolic heat production at 22 h fasting for the beef cow (Young, 1975a).

Prediction equations for ME for broiler breeder hens

- **Equation 1**
- **ME = BW0.75[111.9 - 0.46 T] + 5.6G + 2.45EM**

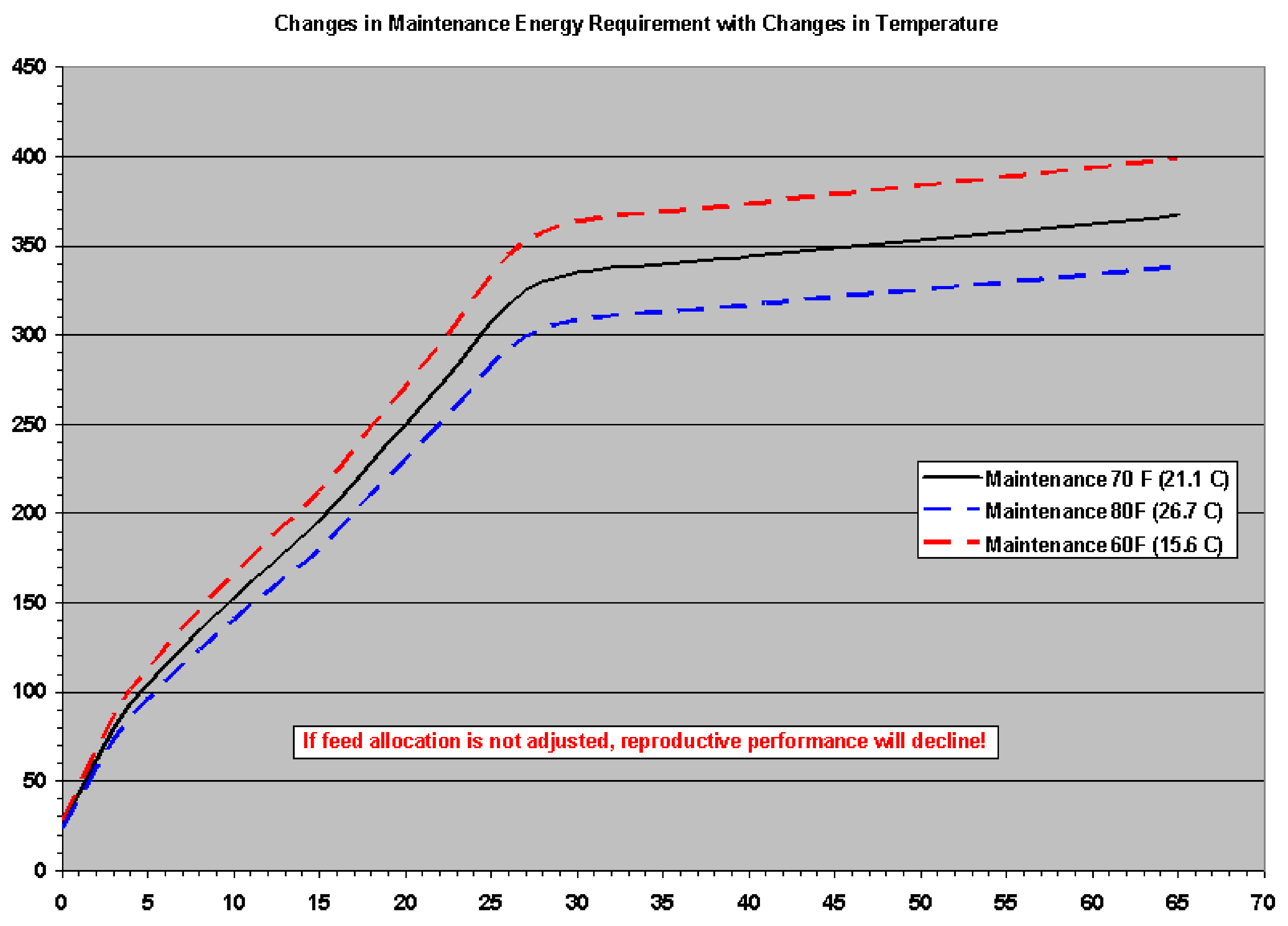
- **Equation 2**
- **ME = BW0.75 [110.3 - 0.47 T °C + 0.055 (T - 22.5)2] + 5.6G + 2.45EM**

- ***ME = metabolizable energy (kcal/kg0.75)***
- ***G = metabolizable energy for body weight gain (kcal/g)***
- ***EM = metabolizable energy for egg mass synthesis (kcal/g)***
- ***T = temperature (oC)***

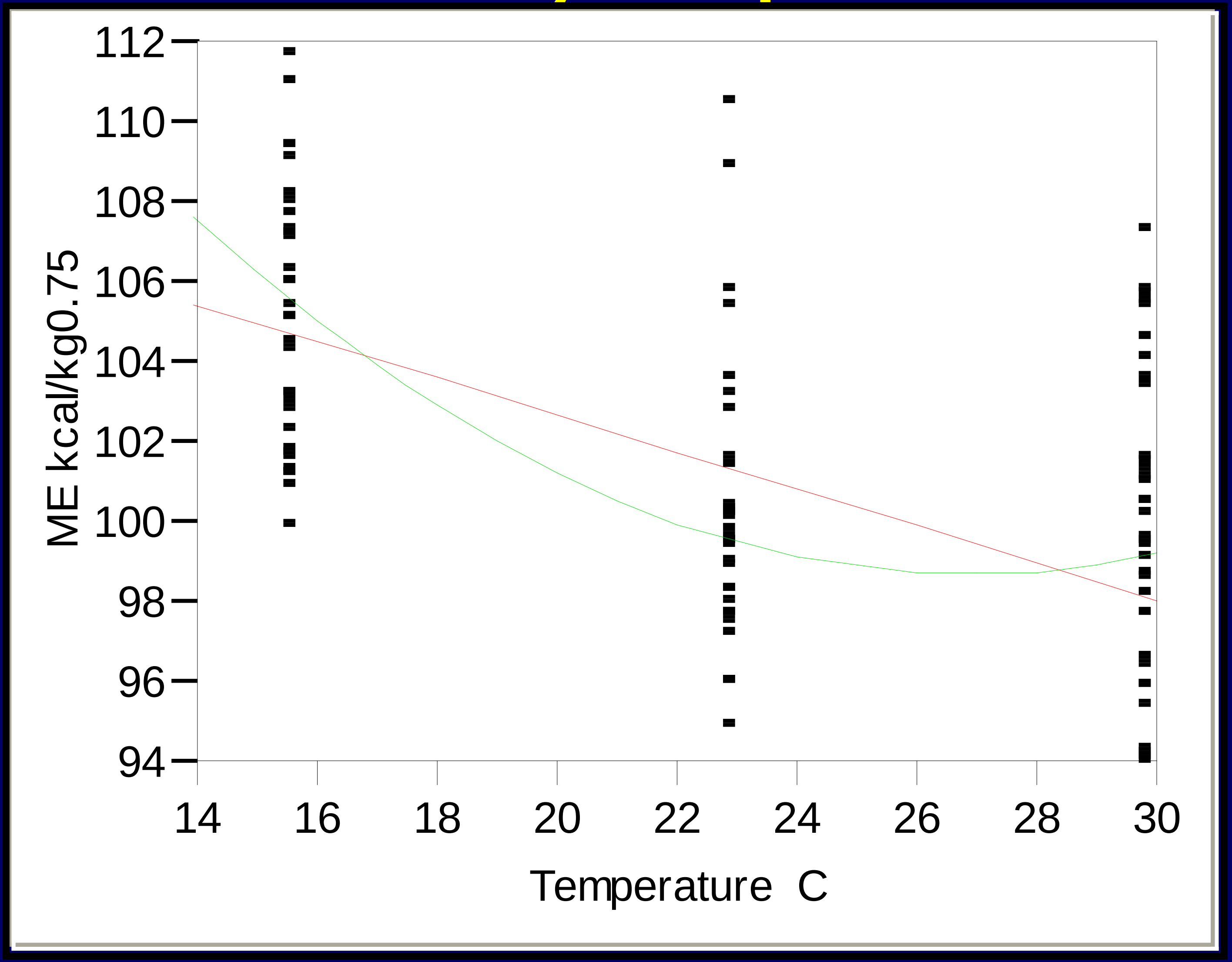
ME Requirements for Broiler Breeders

$$ME = BW^{0.75} [111.02 - 0.49\,T + 0.049\,(T - 22.07)^2] + BW\Delta\,(1/0.77 \times ERf + 1/0.38 \times ERp) + ECE/0.73 \times EM$$

ME = metabolizable energy (kcal); BW = body weight ($kg^{0.75}$); T = temperature (°C); EM= egg mass (kcal/g of egg): BWΔ = body weight change (g/d); ERf = energy retained as fat (kcal); ERp = energy retained as protein (kcal); ECE = energy content of eggs (kcal/g); and EM = egg mass (g).


Changes in Maintenance Energy Requirement with Changes in Temperature
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Maintenance 70 F (21.1 C)
Maintenance 80F (26.7 C)
Maintenance 60F (15.6 C)
If feed allocation is not adjusted, reproductive performance will decline!

ME Requirements of Broiler Breeders as affected by Temperature



Compare ME Models for Predicting Requirements

31 Wks

Cobb 500 Breeder Management Guide: BW = 3.33 kg; BW change = 2.86 g/d; and EM = 46.86 g/d

45 Wks

Cobb 500 Breeder Management Guide: BW = 3.54 kg; BW change = 2.14 g/d; and EM = 43.10 g/d

ME requirements predicted for maintenance of broiler breeder hens at 21C

	ME_m	(kcal/b/d)	
	Reyes, Univ. of Ark.	Spratt et al, 1990	Rabello et al, 2000
31	242	217	278
45	252	226	292

ME requirements predicted for daily BW gain of broiler breeder hens

	$ME_{\Delta BWT}$	(kcal/b/d)	
	Reyes, Univ. of Ark.	Spratt et al, 1990	Rabello et al, 2000
31	16.3	21.4	21.8
45	12.2	16.0	16.3

ME requirements predicted for daily egg mass production of broiler breeder hens

	ME_e	(kcal/b/d)	
	Reyes, Univ. of Ark.	Spratt et al, 1990	Rabello et al, 2000
31	108	131	113
45	99	121	103

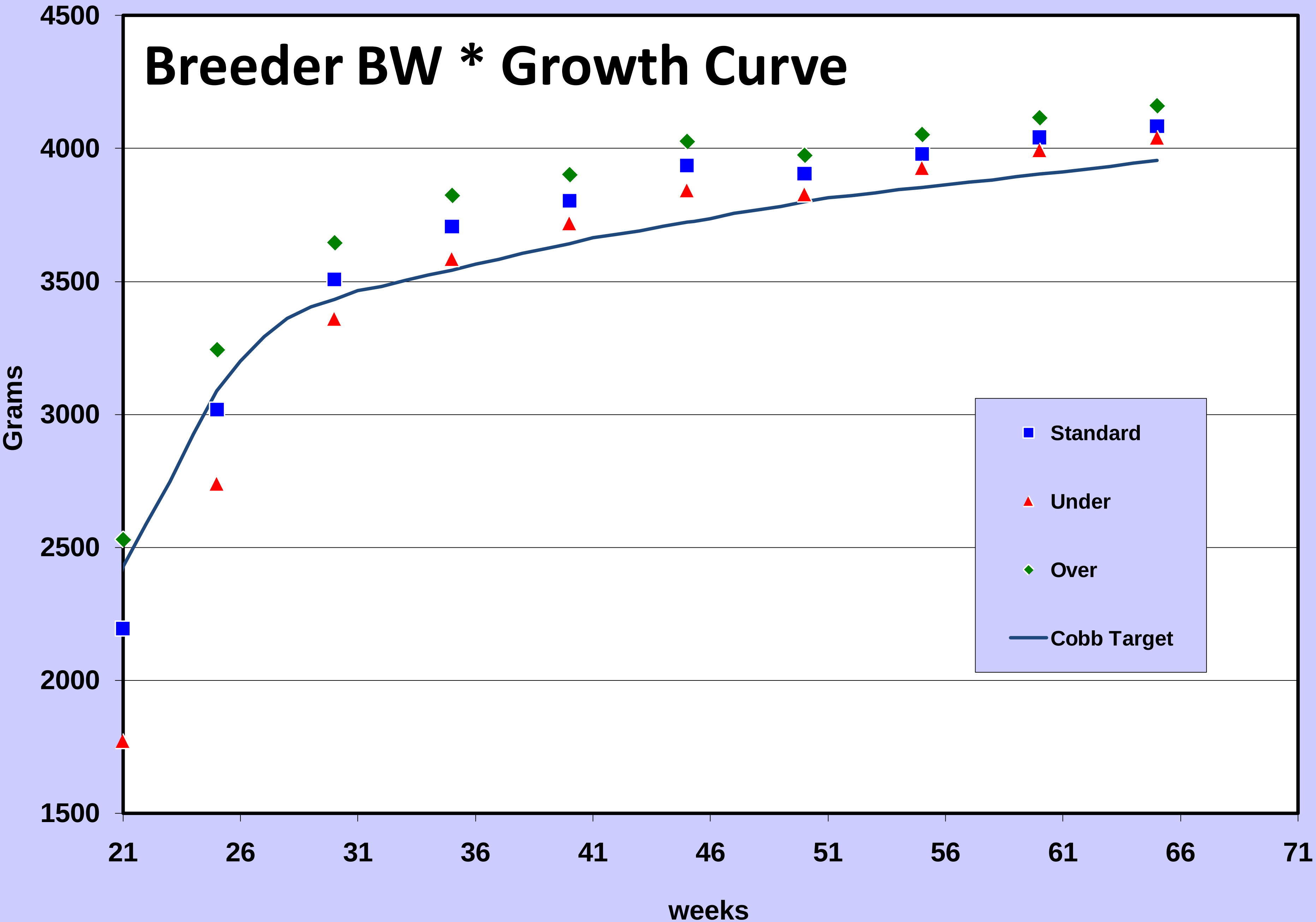
ME requirements predicted for ME_m, $ME_{\Delta BWT}$, and ME_e for broiler breeder hens

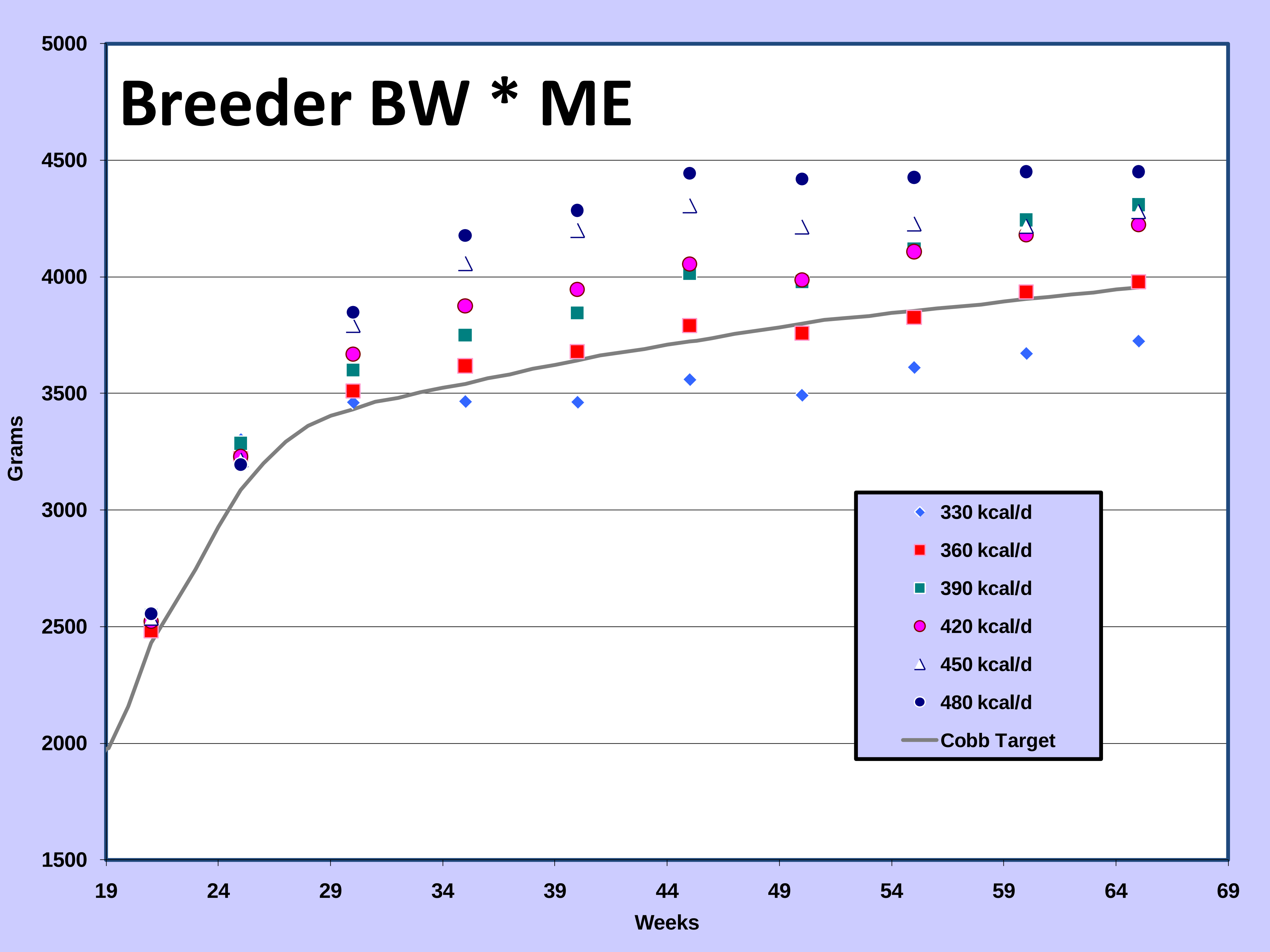
	MEI	(kcal/b/d)	
	Reyes, Univ. of Ark.	Spratt et al, 1990	Rabello et al, 2000
31	366	369	413
45	364	362	412

ME requirements predicted for ME_m, $ME_{\Delta BWT}$, and ME_e plus activity for broiler breeder hens

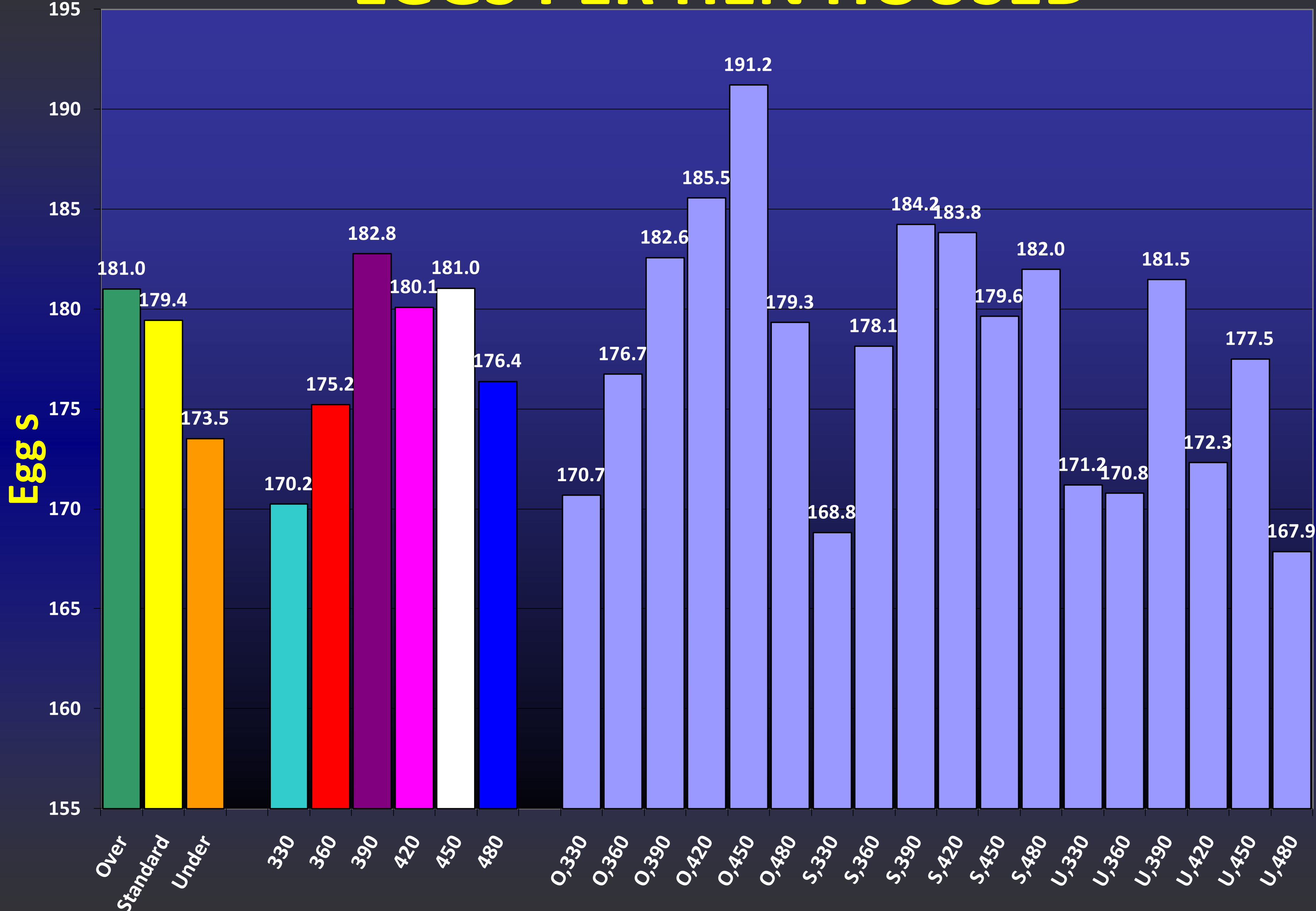
	MEI+Act.	(kcal/b/d)	
	Reyes, Univ. of Ark.	Spratt et al, 1990	Rabello et al, 2000
31	414	419	413
45	414	392	412

Broiler Breeder ME Requirements 2009/2010

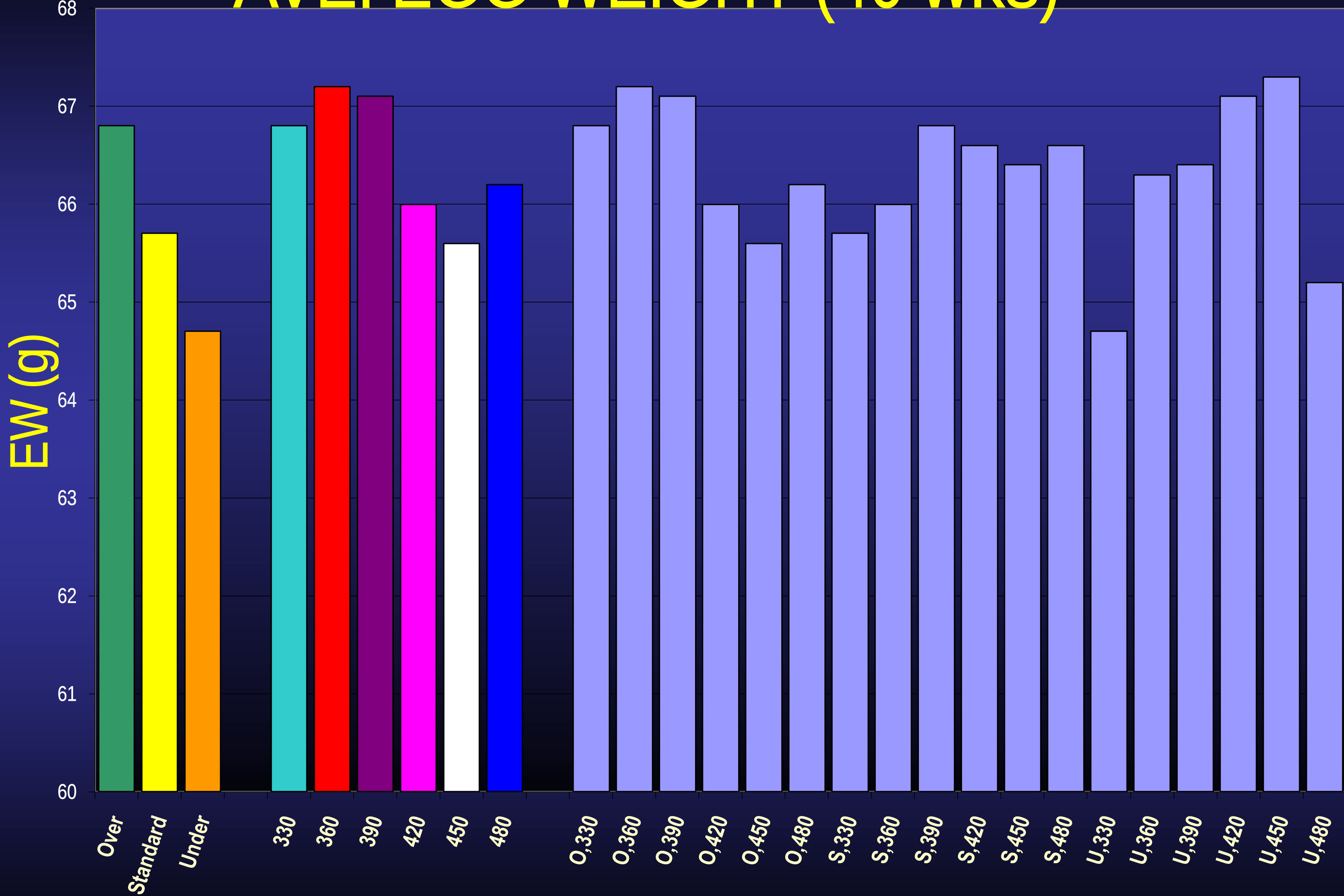

Breeder BW * Growth Curve
4500
4000
3500
3000
2500
2000
1500
Grams
21
26
31
36
41
46
51
56
61
66
71
weeks
Standard
Under
Over
Cobb Target


Breeder BW * ME
5000
4500
4000
3500
3000
2500
2000
1500
Grams
19
24
29
34
39
44
49
54
59
64
69
Weeks
330 kcal/d
360 kcal/d
390 kcal/d
420 kcal/d
450 kcal/d
480 kcal/d
Cobb Target

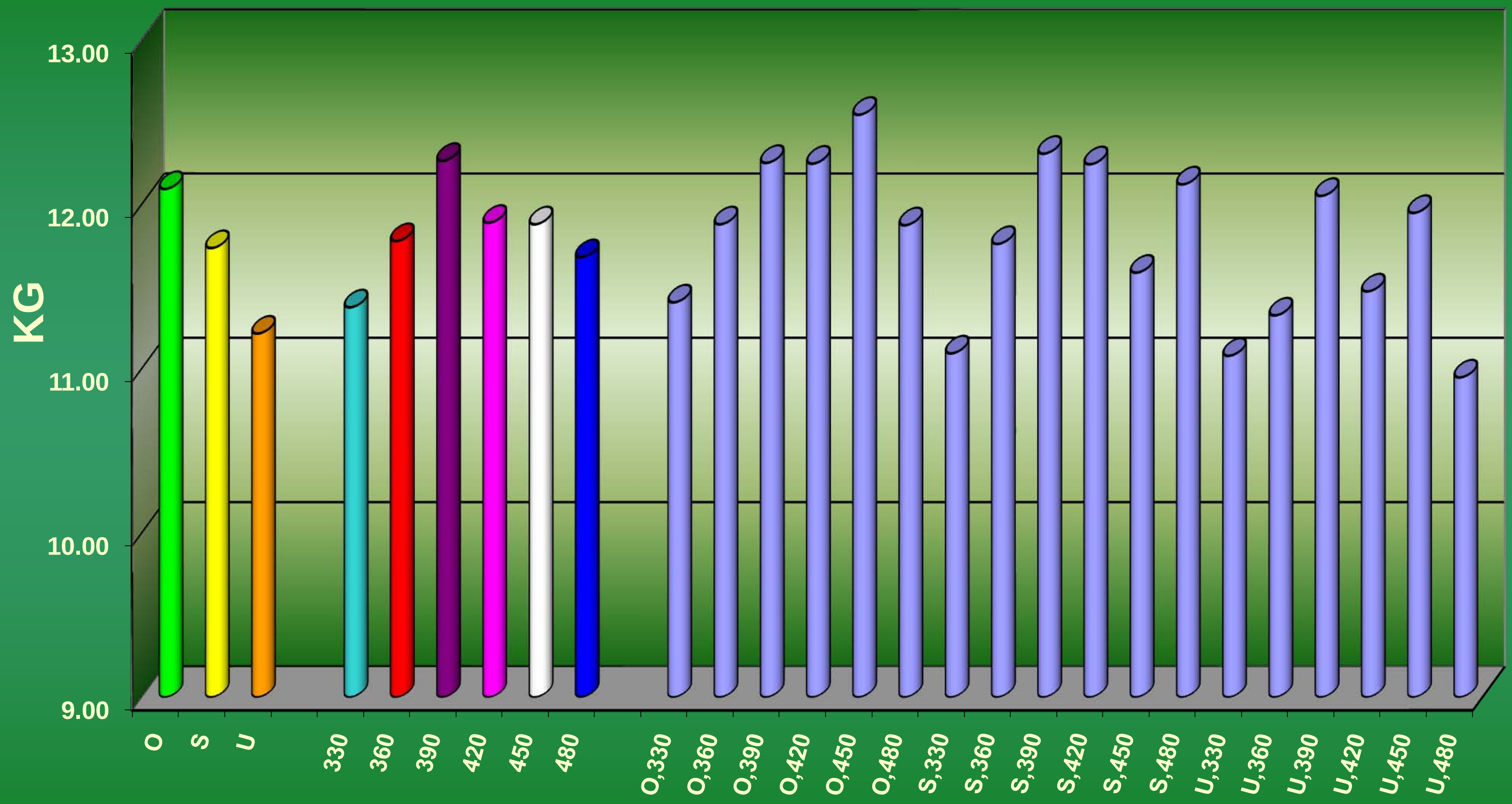
EGGS PER HEN HOUSED



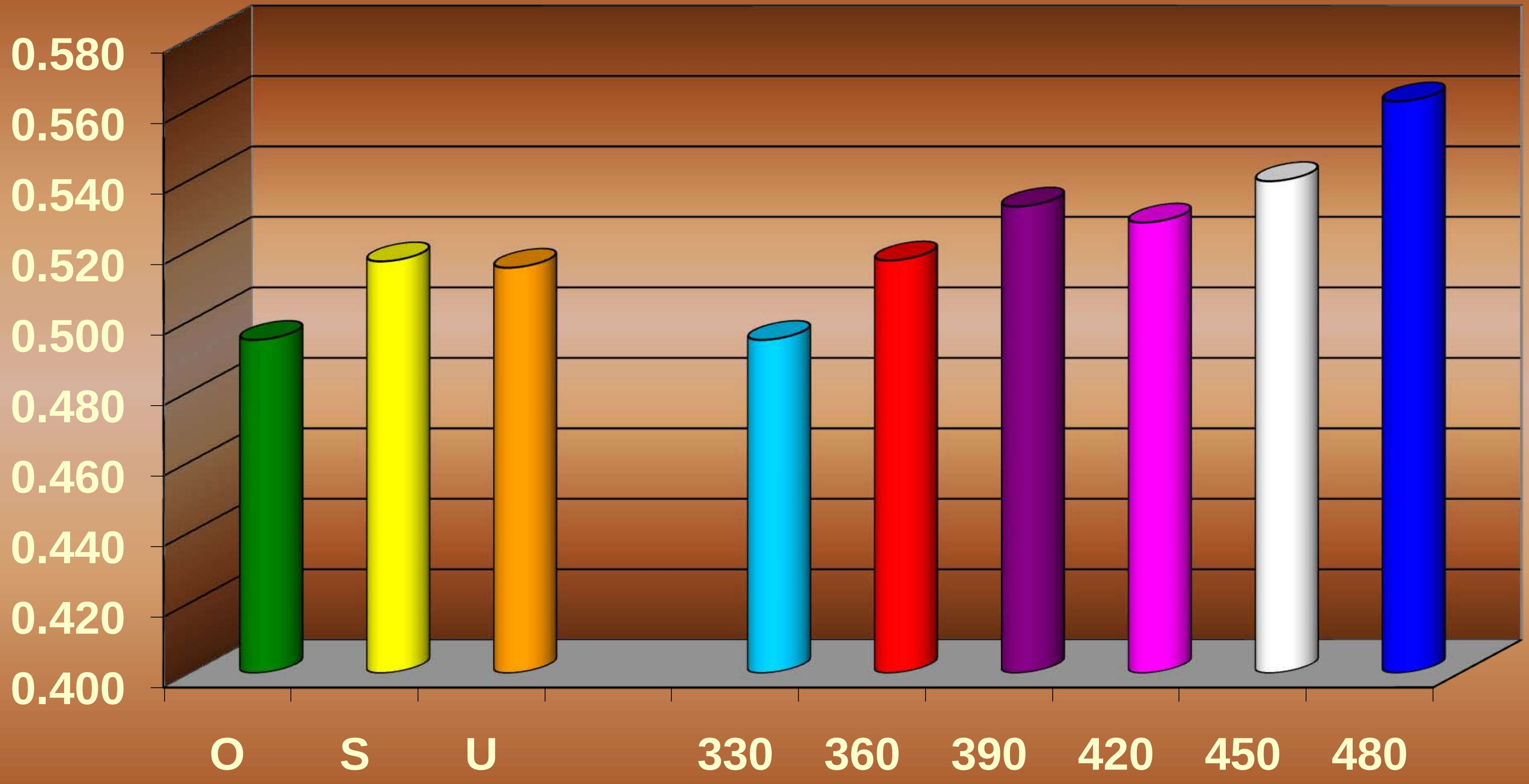
AVE. EGG WEIGHT (40 wks)

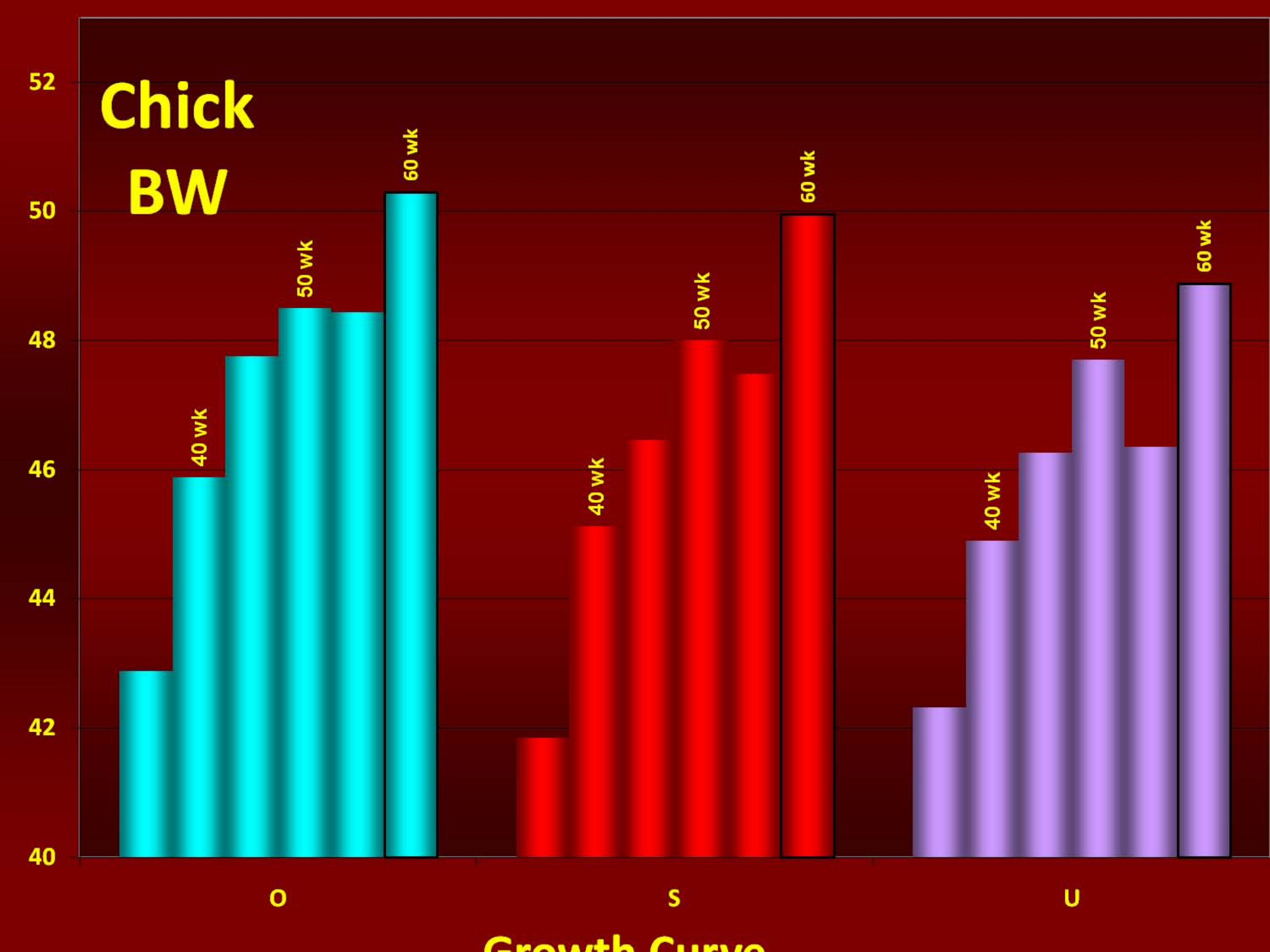


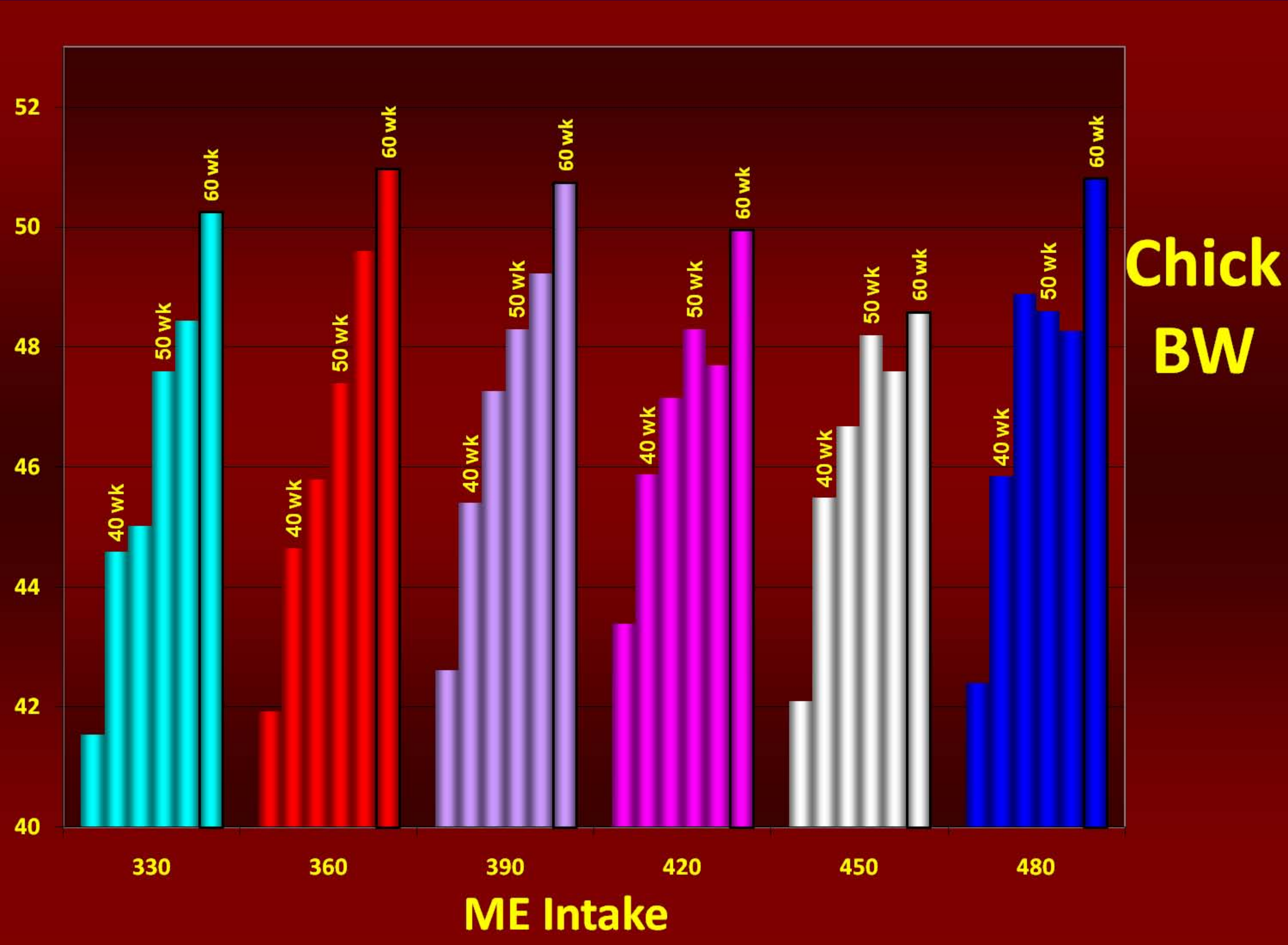
CUMULATIVE EGG MASS (Kg)



YOLK:ALBUMEN RATIO(wet)




Chick
BW
52
50
48
46
44
42
40
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
O
S
U
Growth Curve


52
50
48
46
44
42
40
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
40 wk
50 wk
60 wk
330
360
390
420
450
480
ME Intake
Chick BW

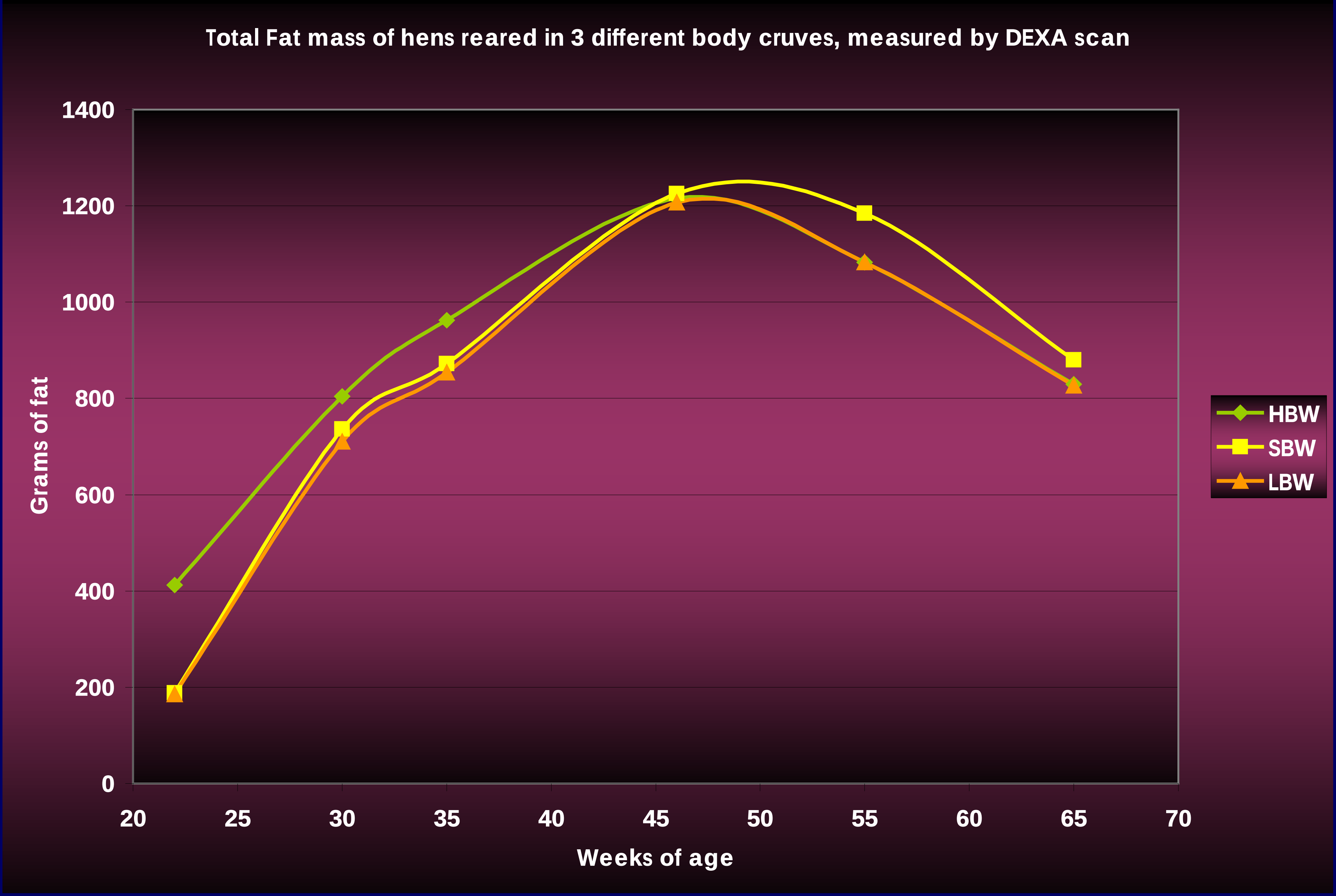
DEXA
Dual Energy X-Ray Absorptiometry

Body Composition Analysis
Total Body Mass (g)
Lean Mass (g),%
Fat Mass (g), %
Total Mineral Content (g), %


LUNAR Prodigy

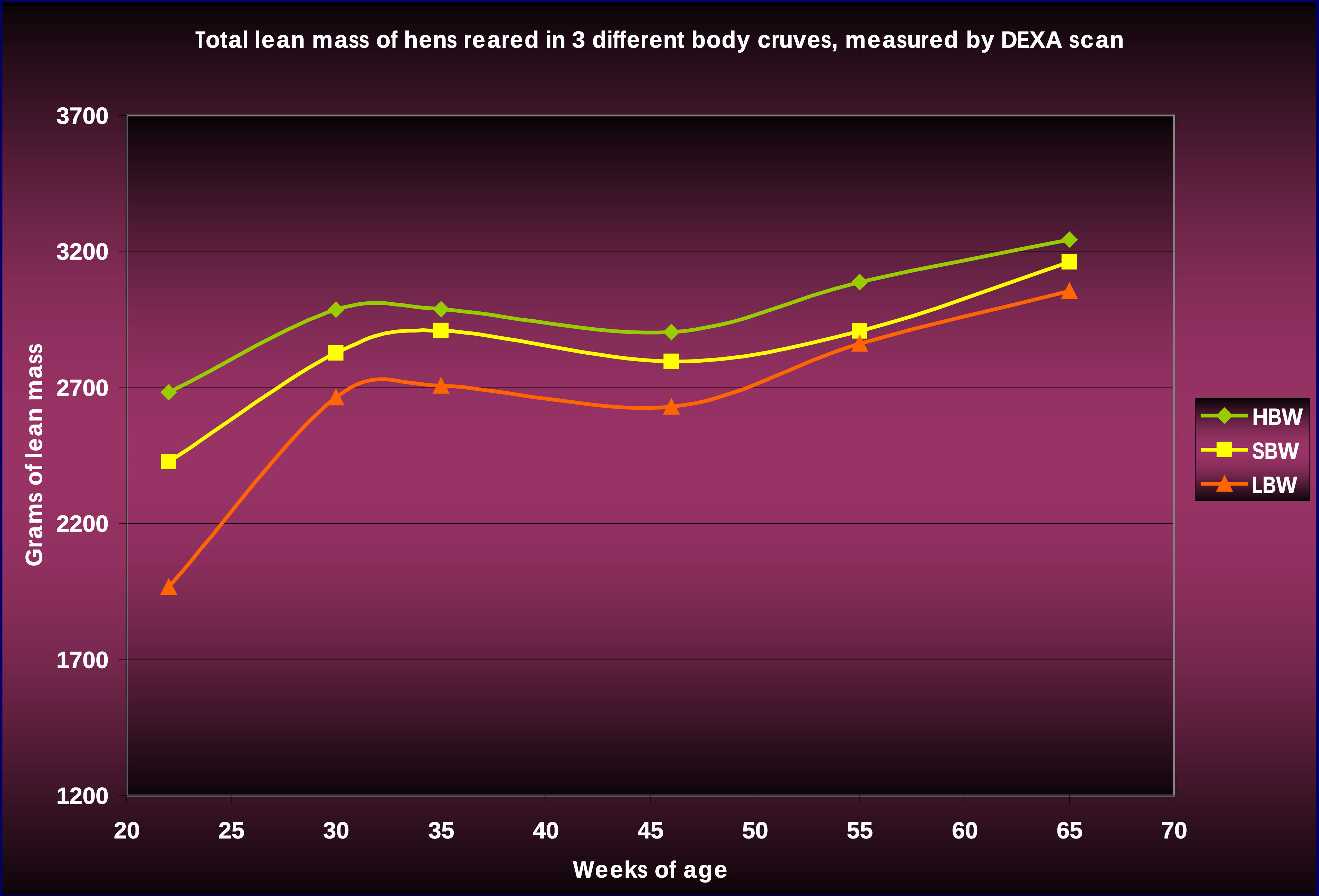
Small Animal Body

Breeder Fat Mass

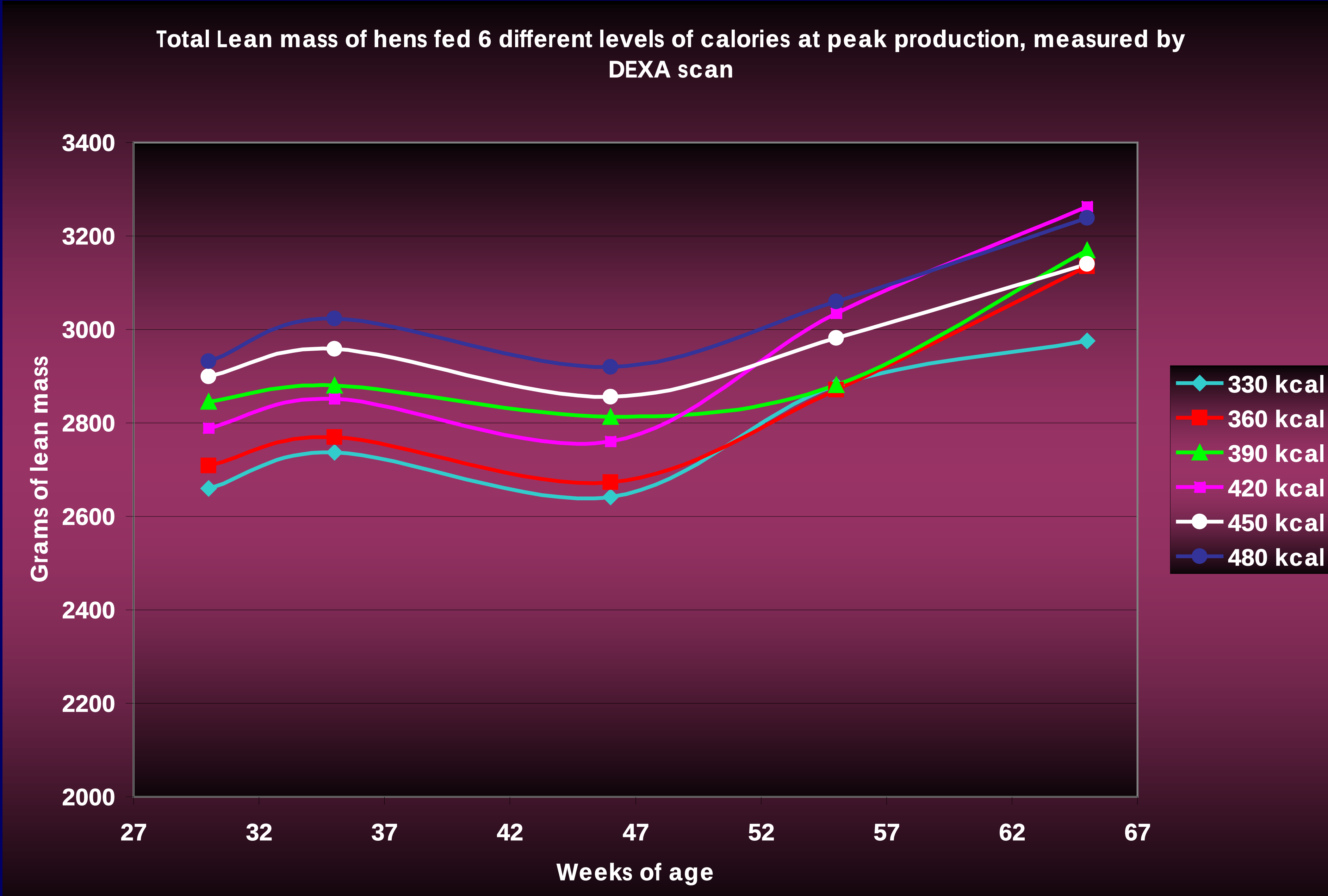


Breeder Fat Mass

Breeder Lean Mass



Breeder Lean Mass



The Amino Acid Requirements for Production and Fertility of Broiler Breeder Hens at Peak Production

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Protein and Amino Acid Requirements for Breeder Hens

- Are we feeding breeder hens enough quality protein and amino acids for maximum production?
- Are we feeding breeder hens too much protein and amino acids for optimum fertility and persistency of lay?

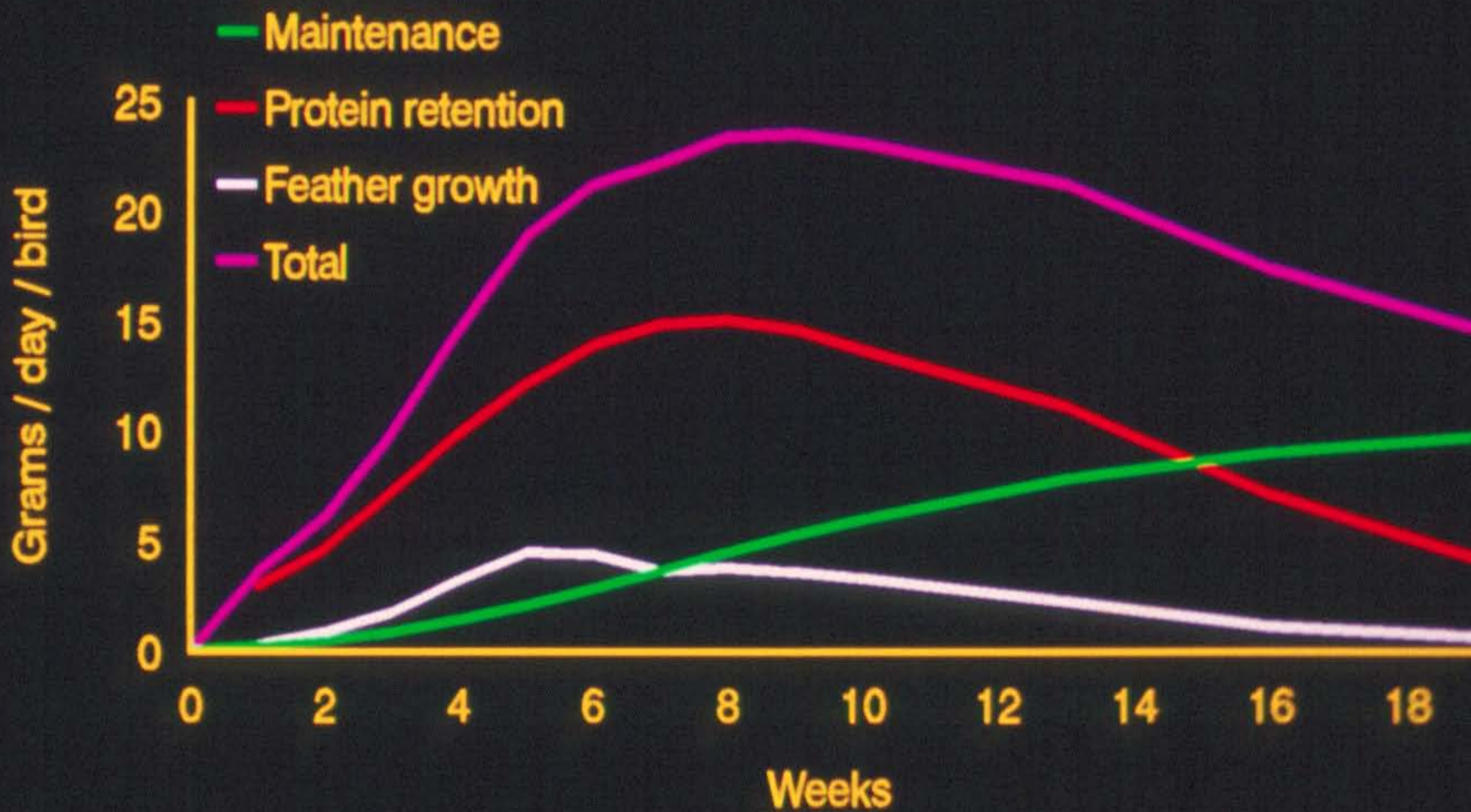
NRC Broiler Breeder Daily Amino Acid Requirements

Nutrient	Unit/breeder/day	Requirement
Protein	g	19.5
Arginine	mg	1110
Histidine	mg	205
Isoleucine	mg	850
Leucine	mg	1250
Lysine	mg	765
Methionine	mg	450
MET + CYS	mg	700
Phenylalanine	mg	610
PHE + TYR	mg	1112
Threonine	mg	720
Tryptophan	mg	190
Valine	mg	750


CHORE-TIME

ARKANSAS BROILER BREEDER STUDIES

Predicting daily protein need for a male broiler



University of Minnesota (1994)

Broiler Breeder AA Maintenance

AA	mg/b/d	mg/kg cp	mg/kg $bw^{.75}$	Ratio
Lys	175.0	333.3	94.2	100.0
Met	99.2	188.3	56.5	56.7
Cys	30.5	75.4	17.0	17.4
TSAA	129.7	263.7	73.5	74.1
Arg	314.4	601.3	173.1	179.6
Thr	242.5	447.7	130.6	138.6
Trp	20.5	35.7	10.7	11.7

Broiler Breeder Ideal AA Maintenance

AA	mg/b/d	mg/kg CP	mg/kg bw$^{.75}$	Ratio
Phe	328.8	575.1	163.9	187.9
Tyr	65.9	175.6	37.2	37.6
Phe+Tyr	394.7	750.7	201.1	225.7
Leu	204.8	400.5	117.1	117.0
Ile	159.0	318.9	92.4	90.8
Val	199.4	336.7	106.3	113.9
His	74.2	139.6	43.6	42.4
NEA	2414.4	6141.2.6	1301.2.2	1379.6

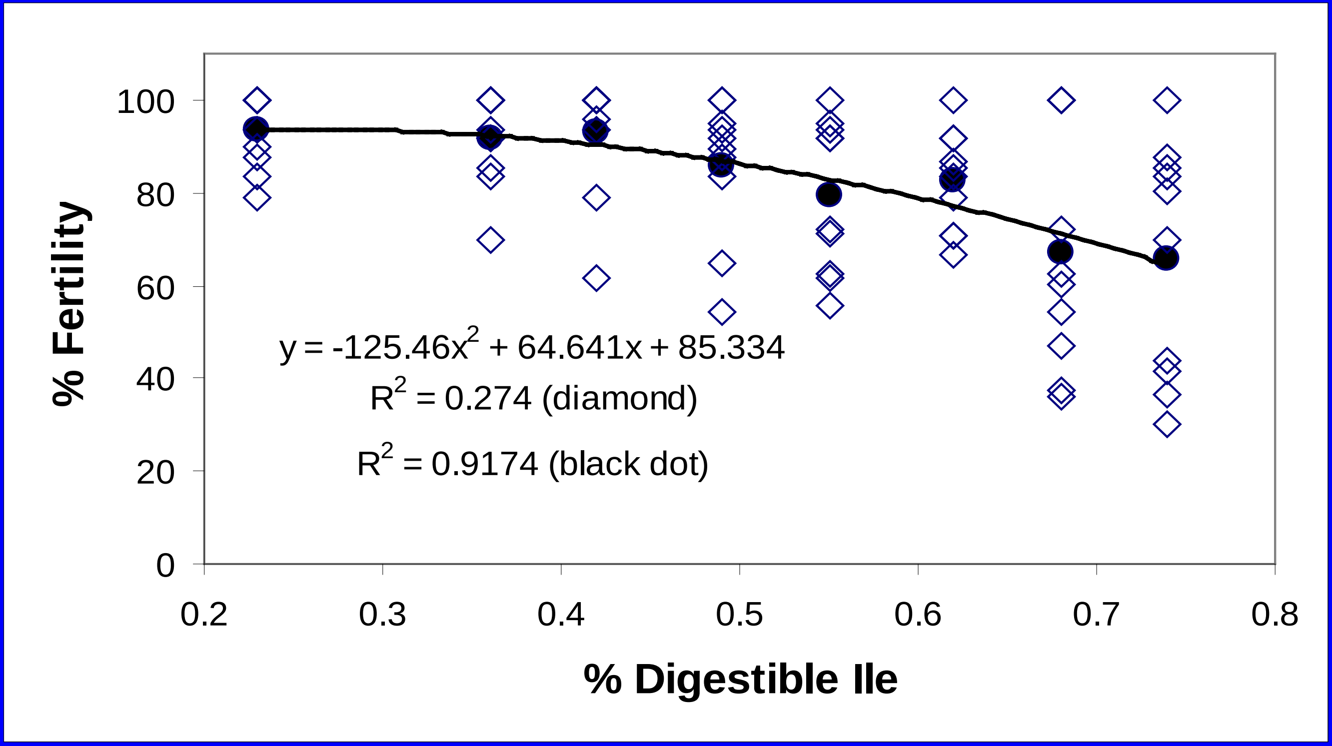
Digestible Amino Acid Requirements at Peak Production

Amino Acid	Maintenance	Production Req. for EM * Minus Maintenance	Production Req. for EM + ΔBW** Minus Maintenance	Total Req. for EM	Total Req. for EM +ΔBW	Fisher (1998) Available	NRC (1994) Total
mg/bird/day							
Crude Protein	5852		13502		19354		19500
Arginine	314	753	708	1067	1022	803	1110
Histidine	74					302	205
Isoleucine	159	689	669	848	828	598	850
Leucine	205					988	1250
Lysine	168	710	721	878	889	893	765
Methionine	91	340	345	431	436	372	450
Cystine	31	395	437	426	468		
Met + Cys						621	700
Phenylalanine	224		475		699		
Tyrosine	66						
Phe + Tyr						1032	1112
Threonine	243	399	370	642	613	558	720
Tryptophan	21	191	222	212	243	186	190
Valine	199	575	587	774	786	693	750
Non-essential AA	4057		7690		11747		
Essential: Non Essential AA Ratio	31:69		43:57		39:61		

Broiler Breeder Ideal AA Profile

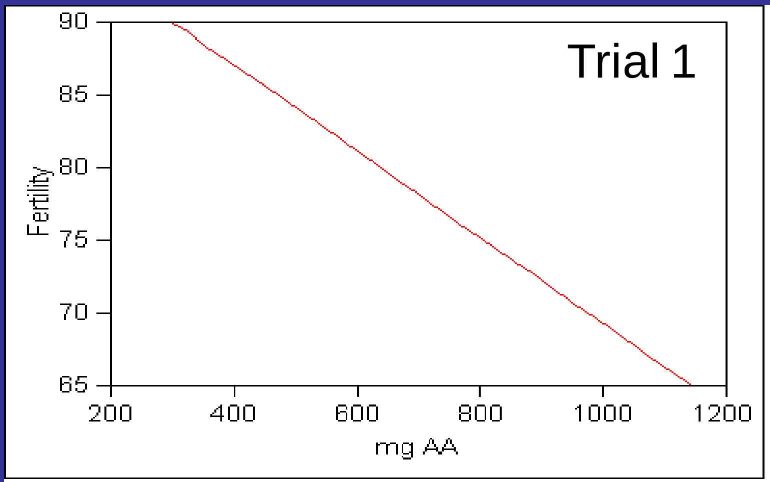
AA	RATIO
LYS	100
ARG	117
MET	53
CYS	53
ILE	97
VAL	92
PHE	78
TRP	29
THR	73

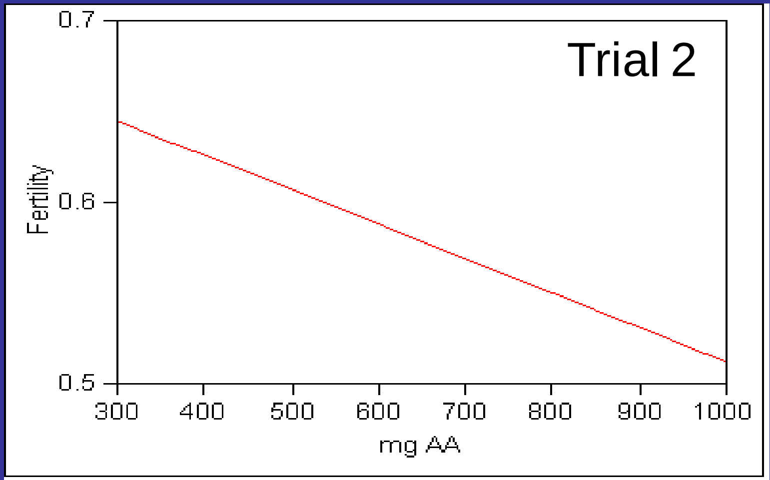
Digestible Isoleucine Requirement for Fertility



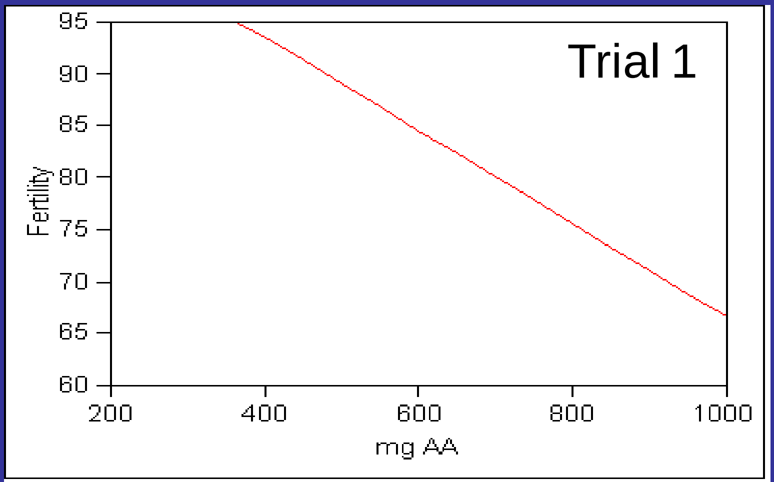
Requirements for Fertility

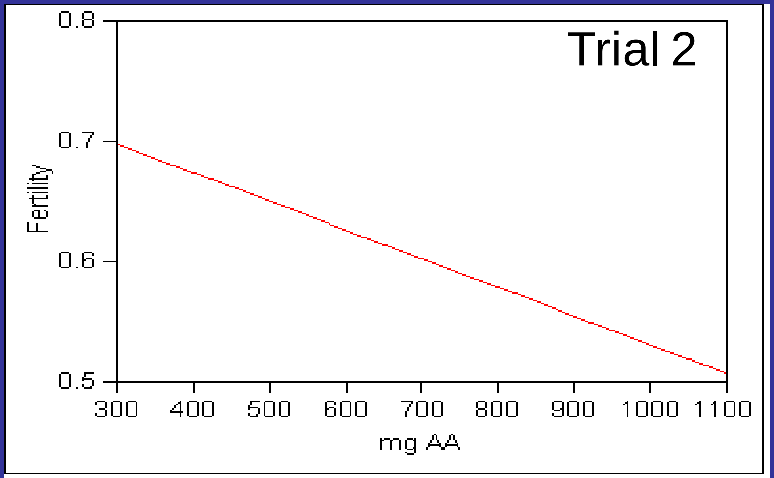
Isoleucine





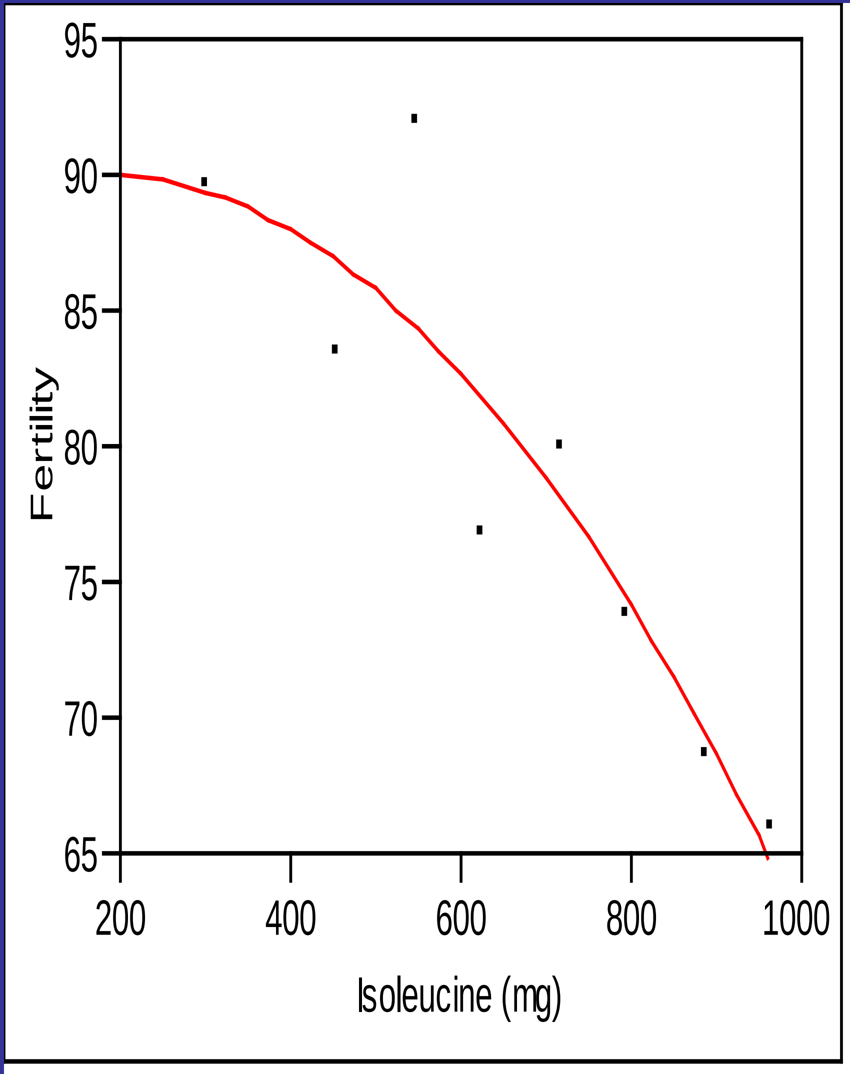
Lysine



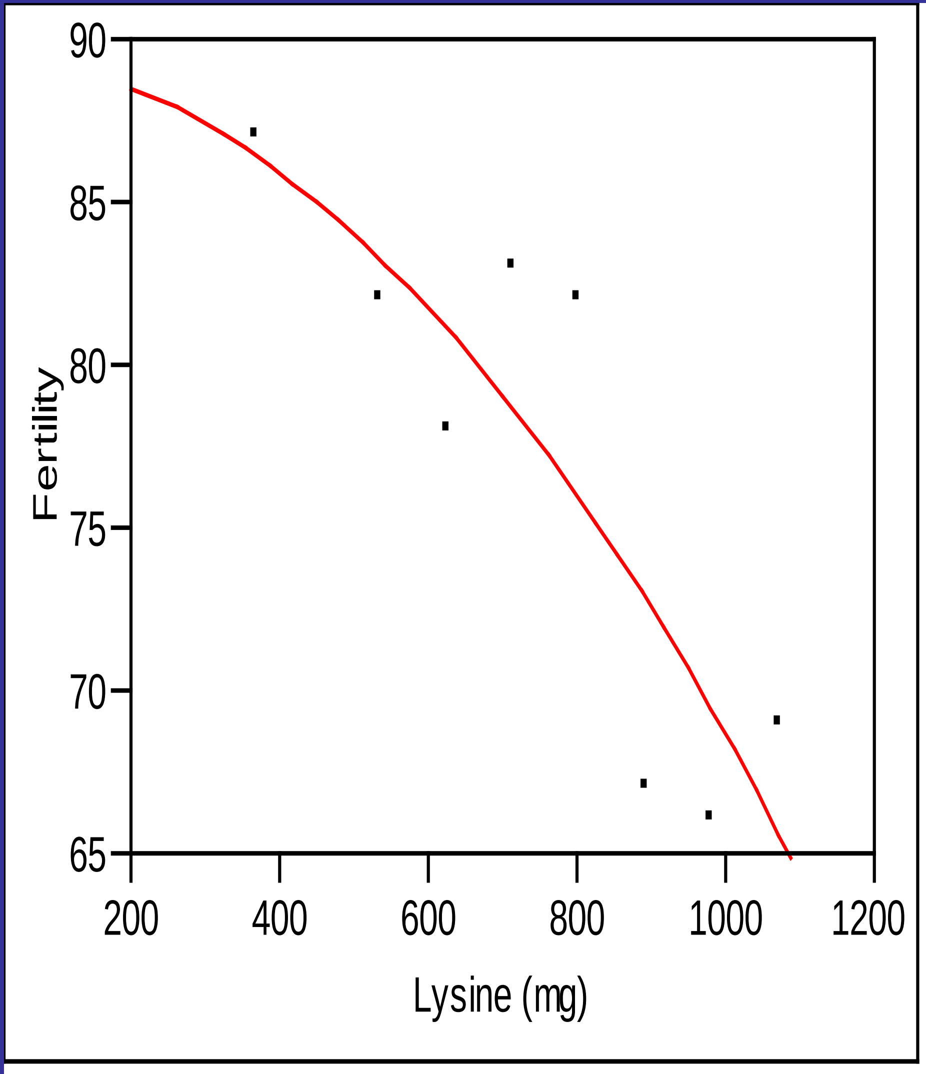


Requirements for Fertility
(3 trials combined)

Isoleucine

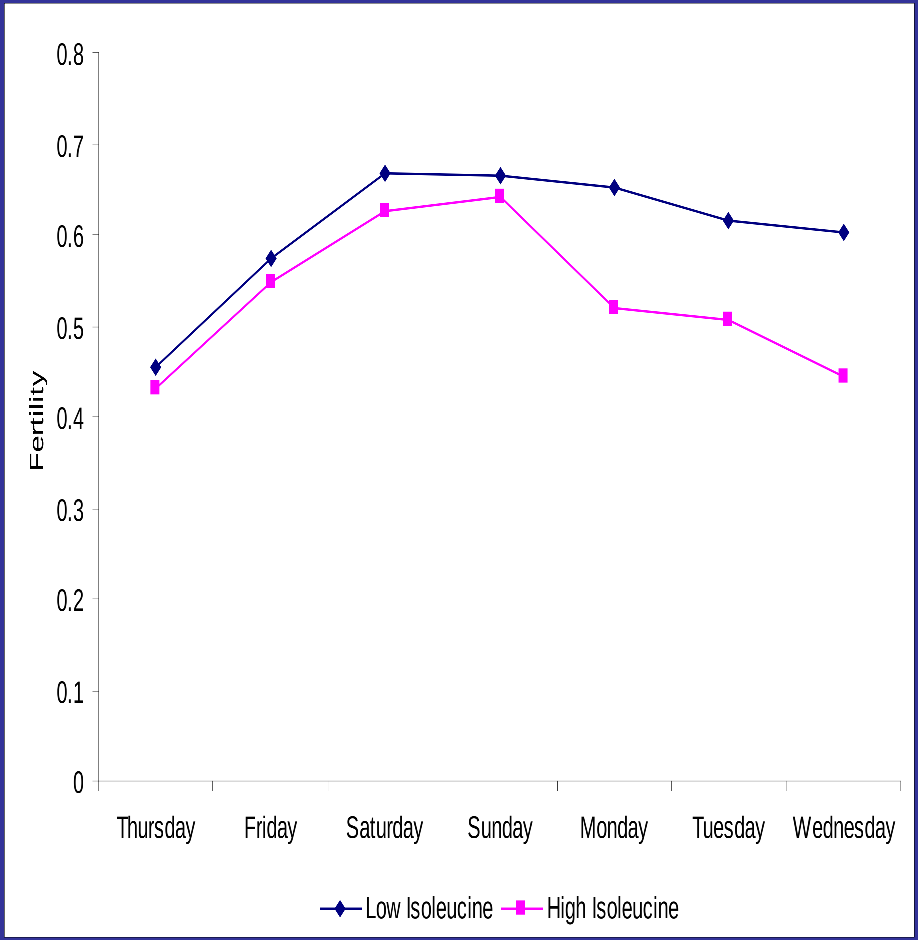


Lysine

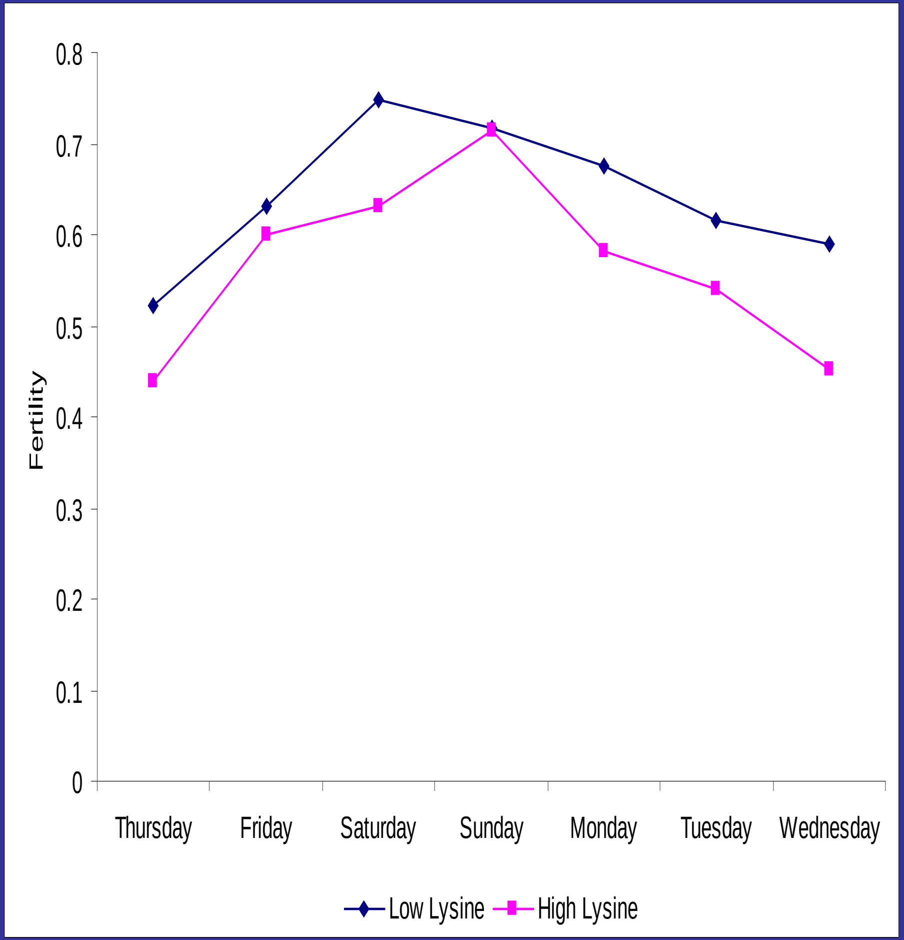


Effect of Days after AI on Fertility

Isoleucine



Lysine

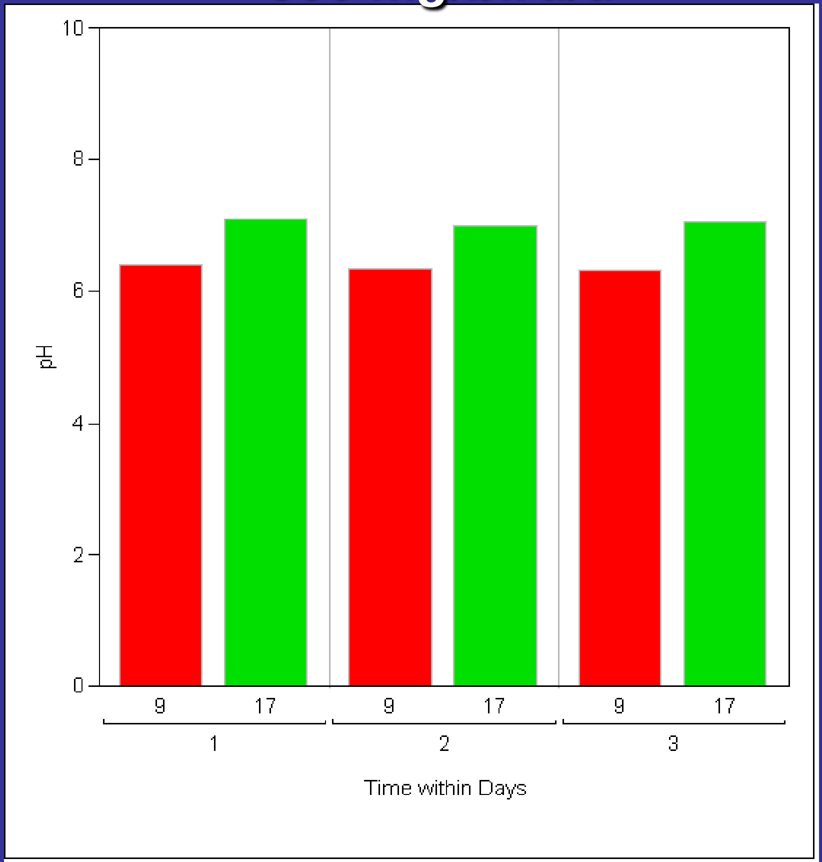


- **Are these effects due to more suitable environment for sperm storage?**
- **Both Isoleucine and Lysine are ketogenic**

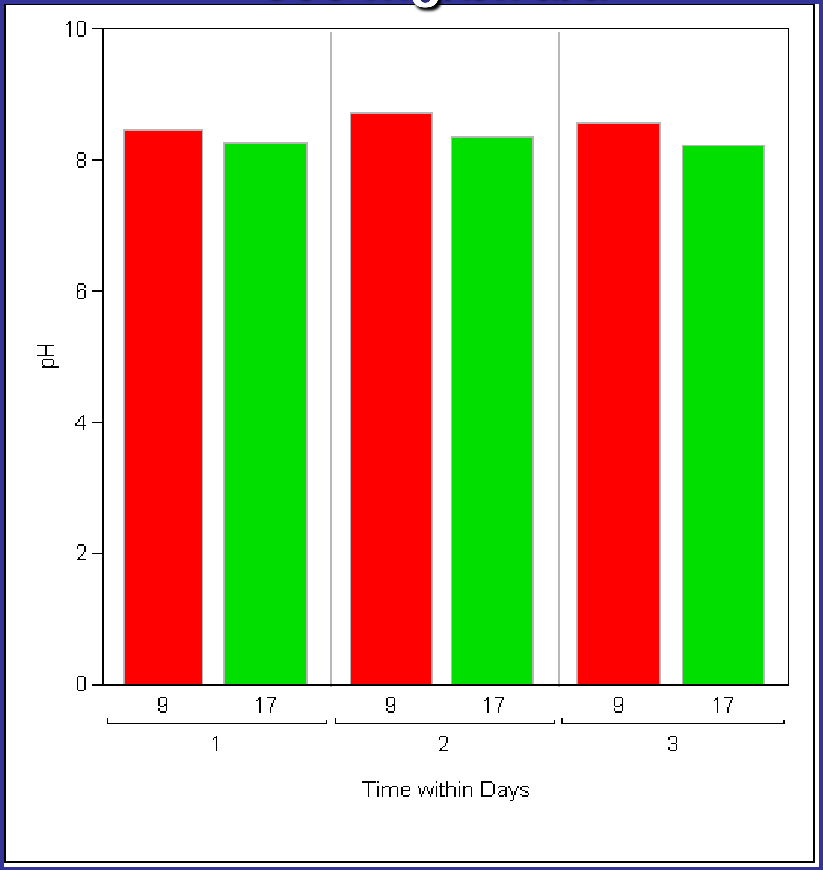
Colostomized broiler breeder hen showing the presence of egg in the urine-collection bag immediately after egg-laying

Urine pH of Colostomized Breeders

Low Isoleucine Diet
300 mg/bird/d



Standard Isoleucine Diet
800 mg/bird/d



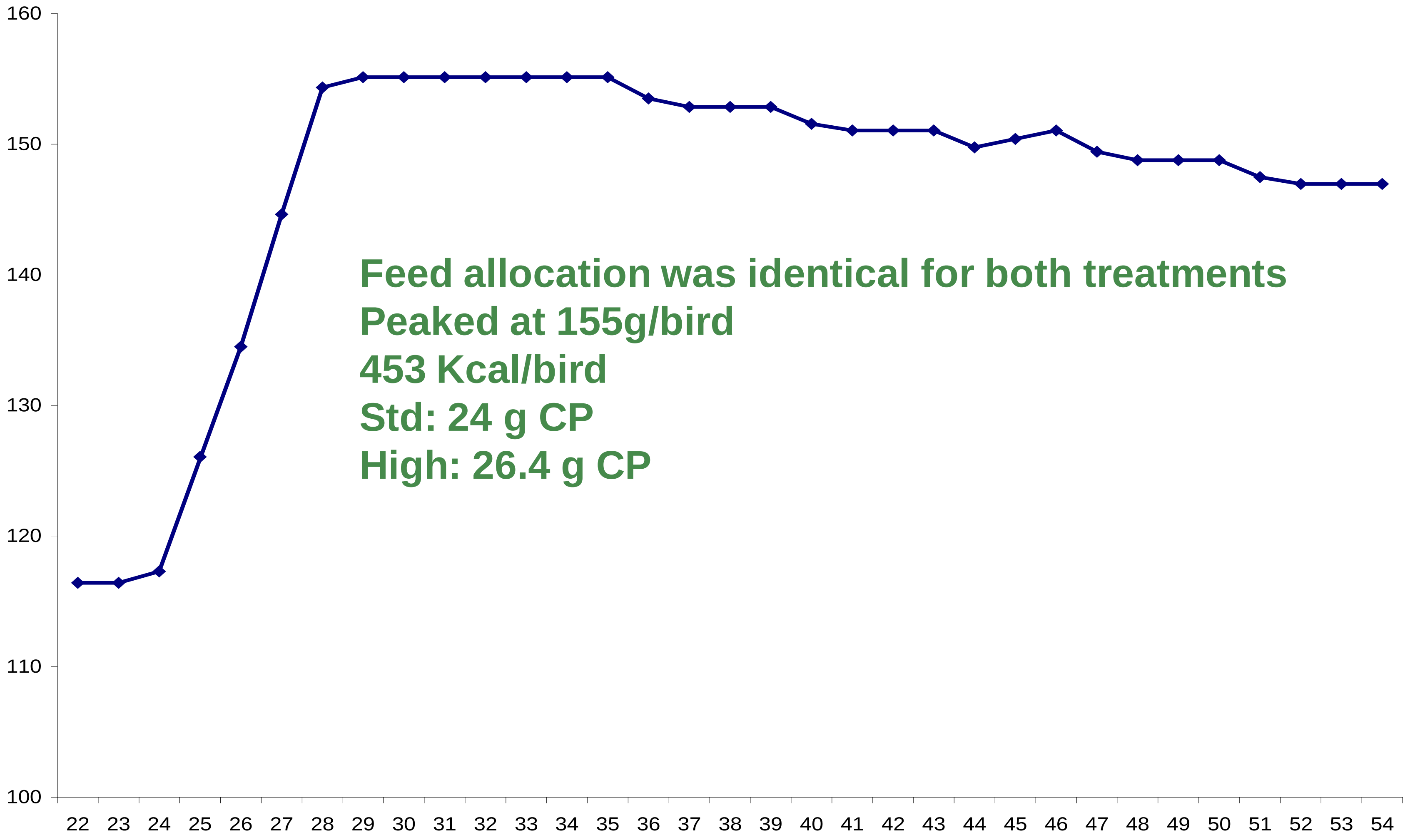
Excess Protein and Heat Stress

- Excess protein must be metabolized, this requires energy, which generates heat. This aggravates heat stress under hot conditions
- Under hot conditions:
  - Body temp will rise by 1ºC - 1 to 3hrs after feeding
  - Reduce excess crude protein
  - Utilize highly digestible ingredients
  - Utilize additional fat to meet Energy levels (replace some of the grain with fat- beware of pellet/crumble quality)

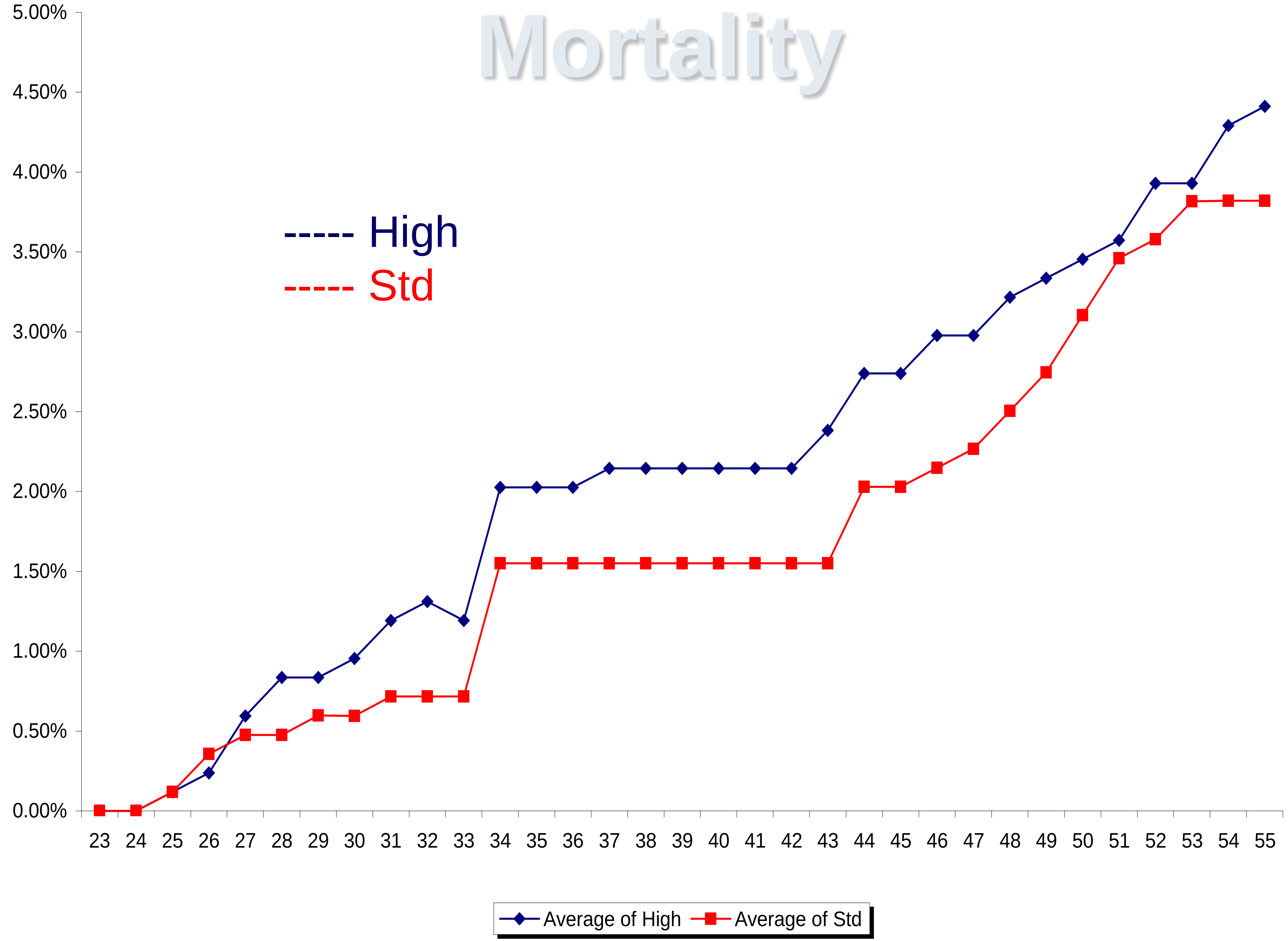
Aviagen Breeder Trial

- Ross 308 Parent Stock
- Crude protein levels tested
- 15.5% vs 17%
- Dig Met+Cys identical in both diets
- Recorded all aspects of performance

Feed Allocation

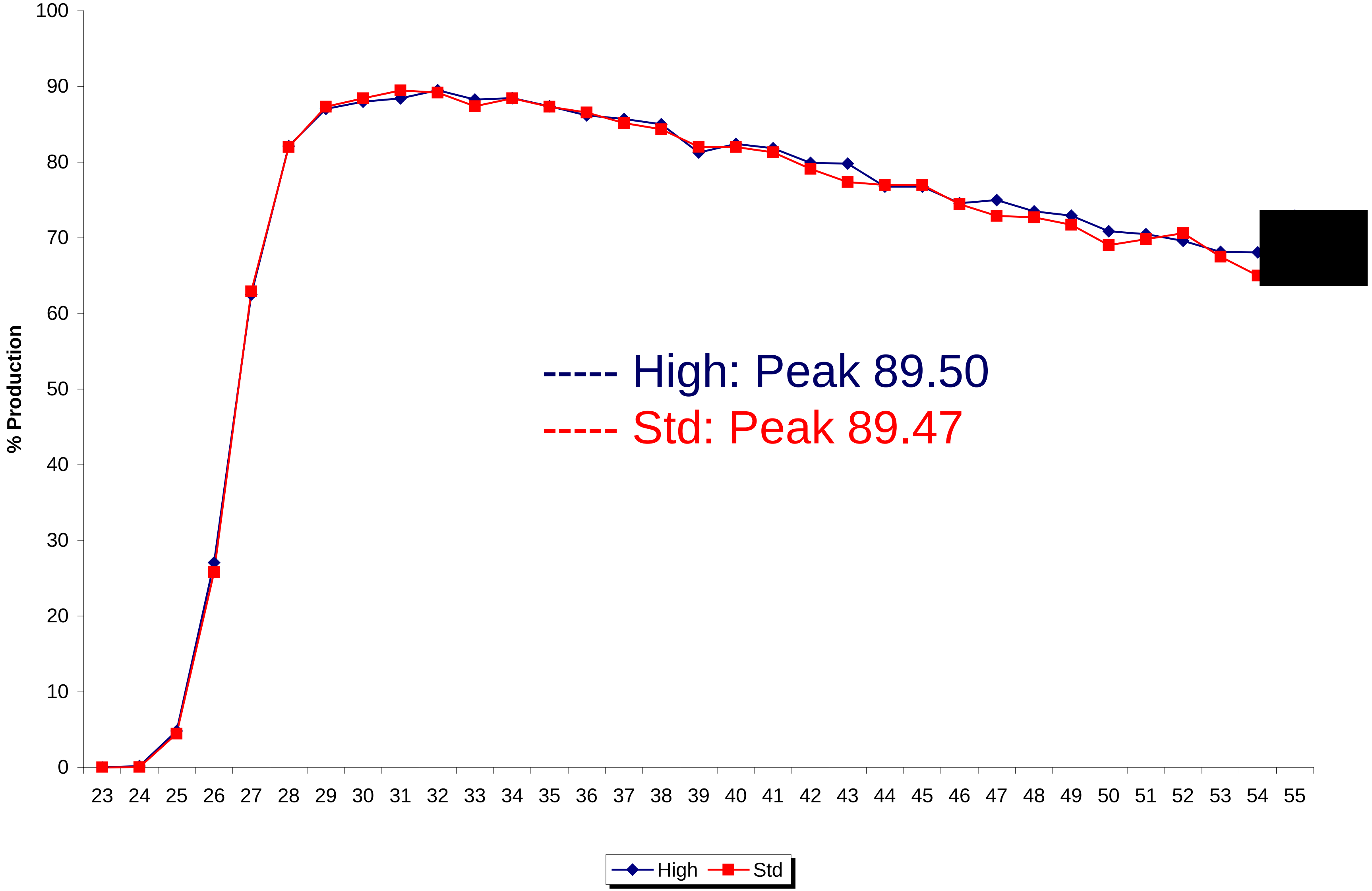


Feed allocation was identical for both treatments
Peaked at 155g/bird
453 Kcal/bird
Std: 24 g CP
High: 26.4 g CP

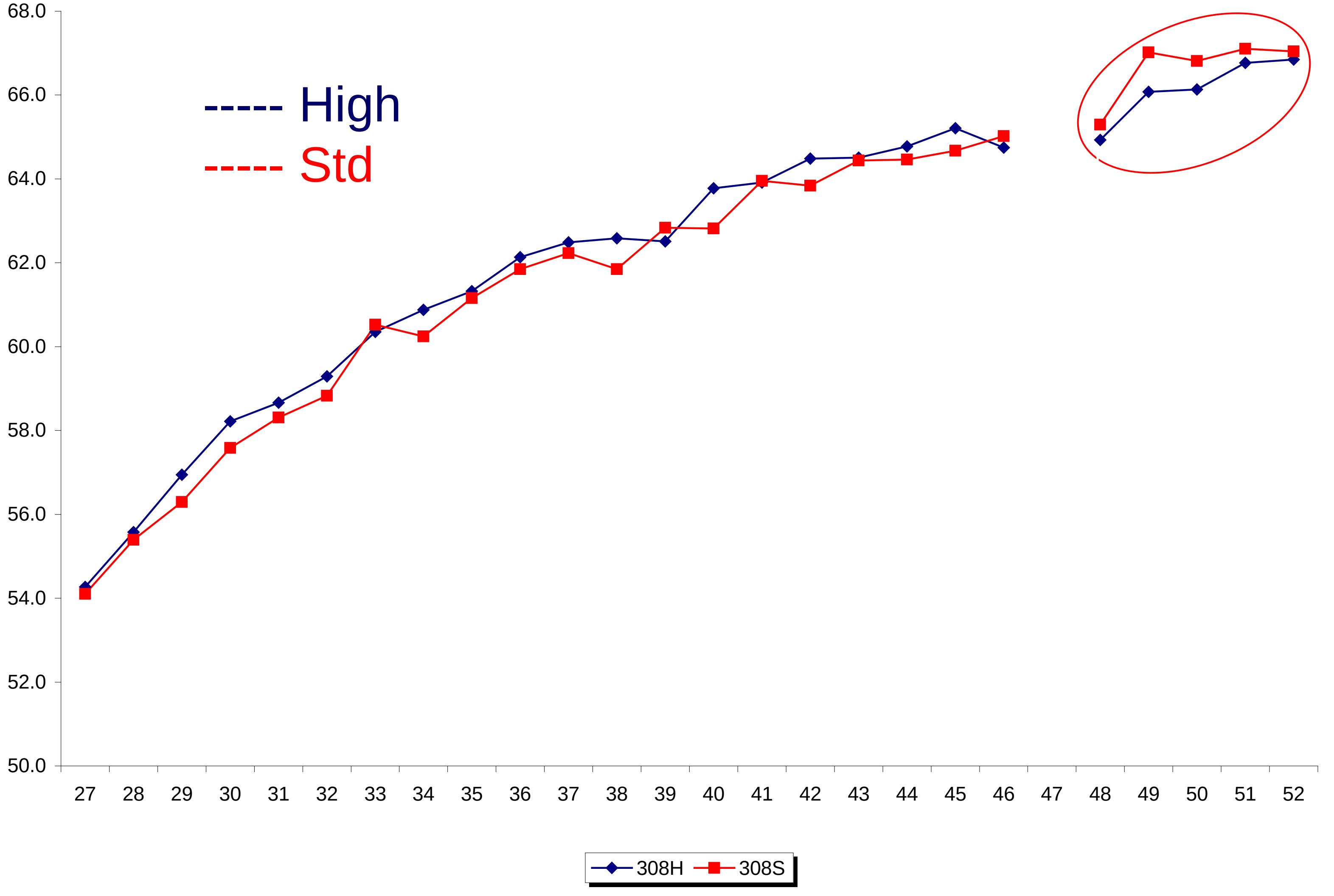


Mortality
----- High
----- Std
5.00%
4.50%
4.00%
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
Average of High
Average of Std

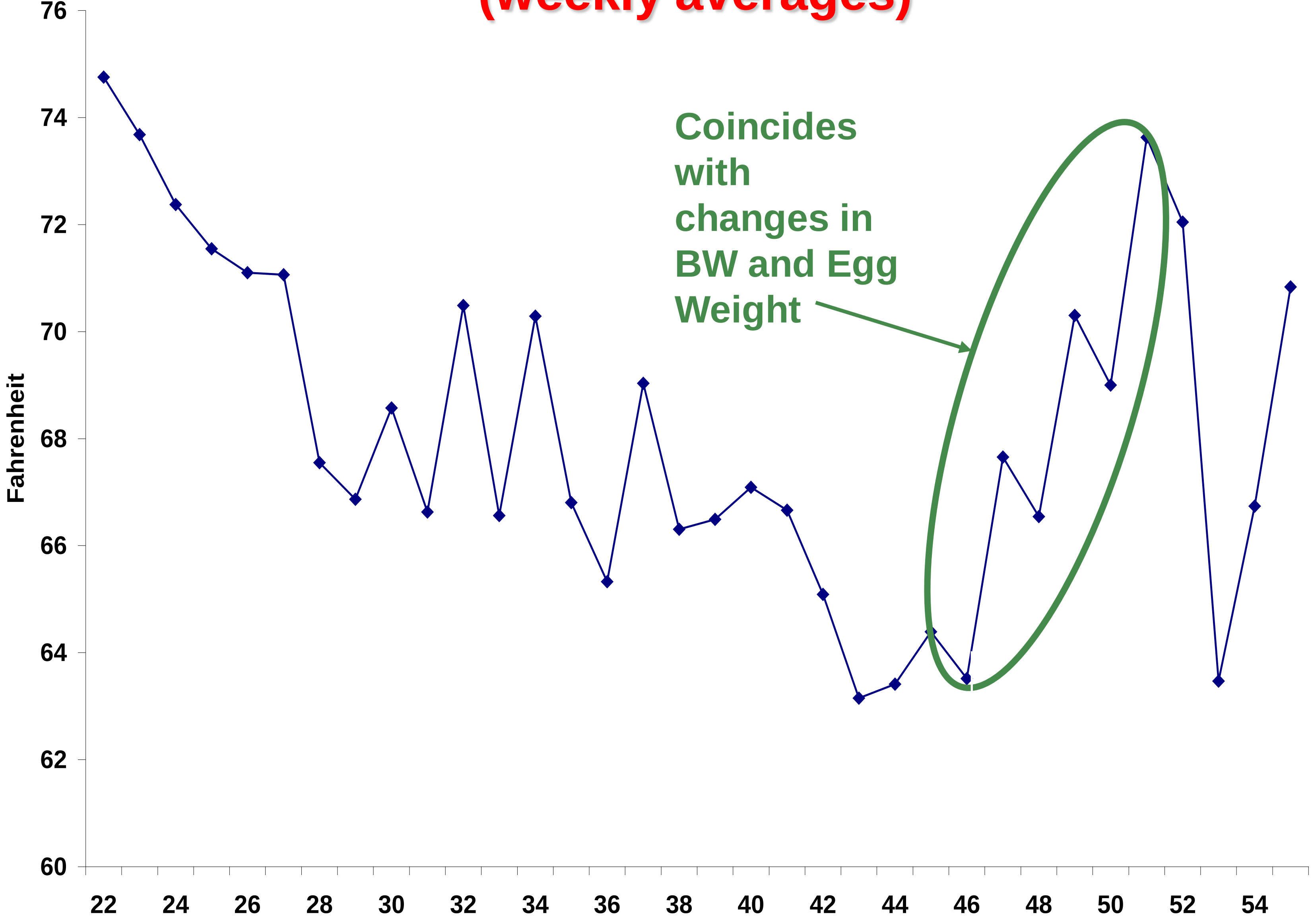
Hen Day Egg Production



Weekly Egg Weights



Temperature
(weekly averages)



Performance Summary

	TE/HH	HE/HH	% HE	Fer-tility %	HOF %	HOS %	Chick Weight g	Mor-tality %	g CP/ dozen HE
Std	157.8	148.5	94.1	92.6	92.1	85.3	40.71	3.93	**434**
High	158.8	148.5	93.5	92.9	91.8	85.3	40.86	4.54	**478**

Protein requirements

- Recent research suggests that the accepted levels of dietary protein may be higher than needed (Coon et al., 2006)
- Impact of overfeeding may include:
  - Alteration of pH and impact on fertility
  - Increased physiological load on kidneys
  - Excessive egg size for hatchery equipment
  - Possible impact on bone quality
  - Increased cost

Fractional synthesis rate

- Fractional synthesis rate (FSR) is the proportion of whole body protein that is synthesized each day
- FSR of breast muscle in layer is ~15%
- FSR of breast muscle in breeder is ~32%, but declines with egg production
- FSR of liver proteins increases with egg production

Manangi, 2007, Hiramoto, 1989

Fractional degradation rate

- Breeders increase protein degradation rate in breast muscle 160% at sexual maturity and decrease the fractional growth rate 5.3X

Manangi et al, 2006 (PSA)

Protein synthesis and degradation rates in pectoralis major muscle and liver of broiler breeder hens before and after sexual maturity

	---Muscle----	---Muscle----	---Muscle----	----Liver---
	k_s, %/d	k_g, %/d	k_d, %/d	k_s, %/d
22 wk	38.96[a]	18.63[a]	20.32[a]	79.65[a]
26 wk	32.83[a]	3.52[b]	32.52[b]	106.36[b]
PSEM	2.99	1.18	1.90	7.79

[a-b] Means within a column with no common superscripts differ significantly ($P < 0.05$)
k_s = fractional rate of protein synthesis; k_g = fractional growth rate; k_d = fractional degradation rate

Manangi et al., 2007 (PSA)

Methods

- 15 Cobb 500 broiler breeders
  - 6 hens euthanized after 2nd egg (trt. 1)
  - 6 hens euthanized after 3rd egg (trt. 2)
  - 3 control hens with no isotope enrichment

Wk 23:
Daily oral dose of ^{15}N-lysine begins

Wk 24

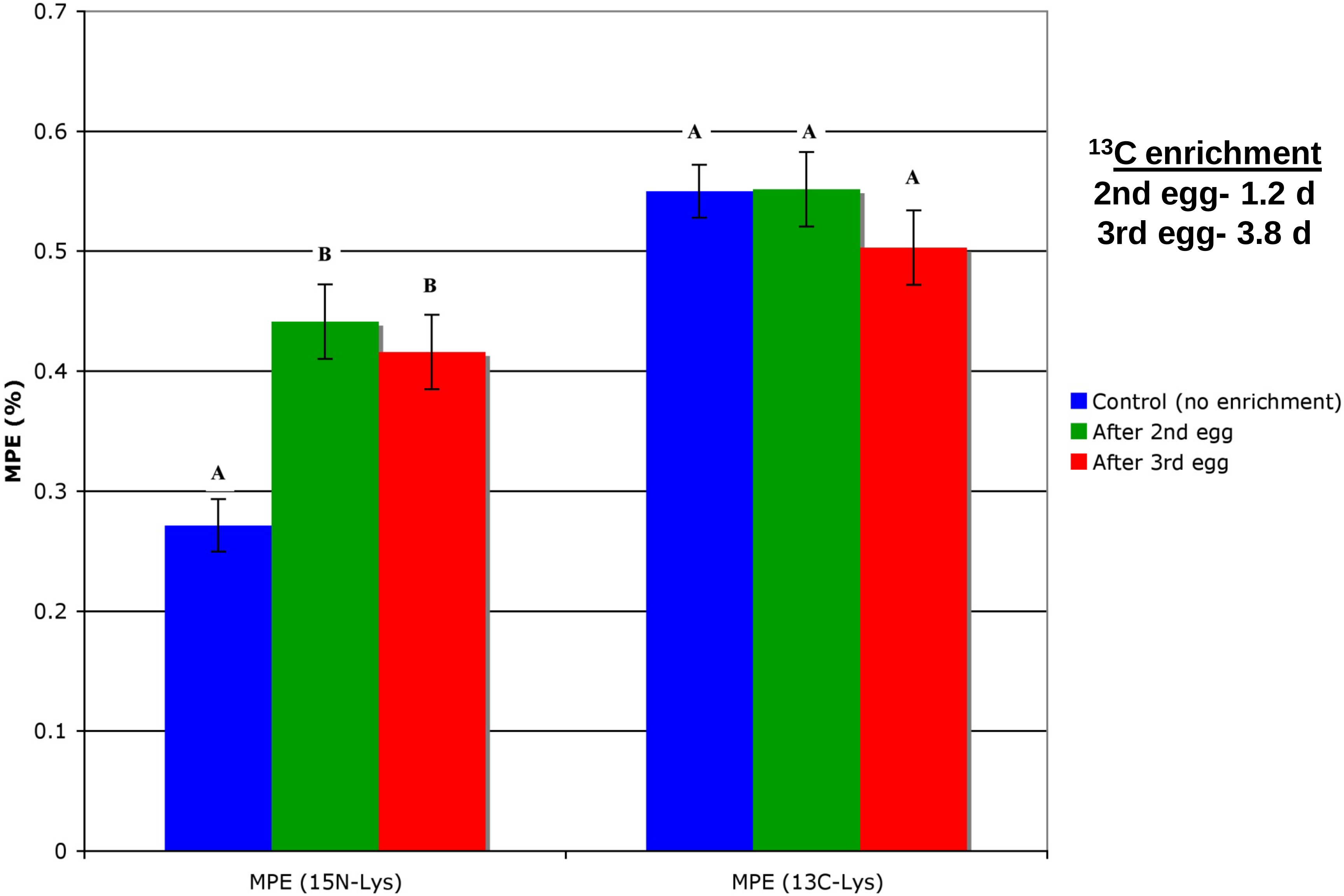
Wk25

Wk 26:
Approximate age of 1st egg; begin Daily oral dose of ^{13}C-lysine ;stop ^{15}N-lysine

Wk 27

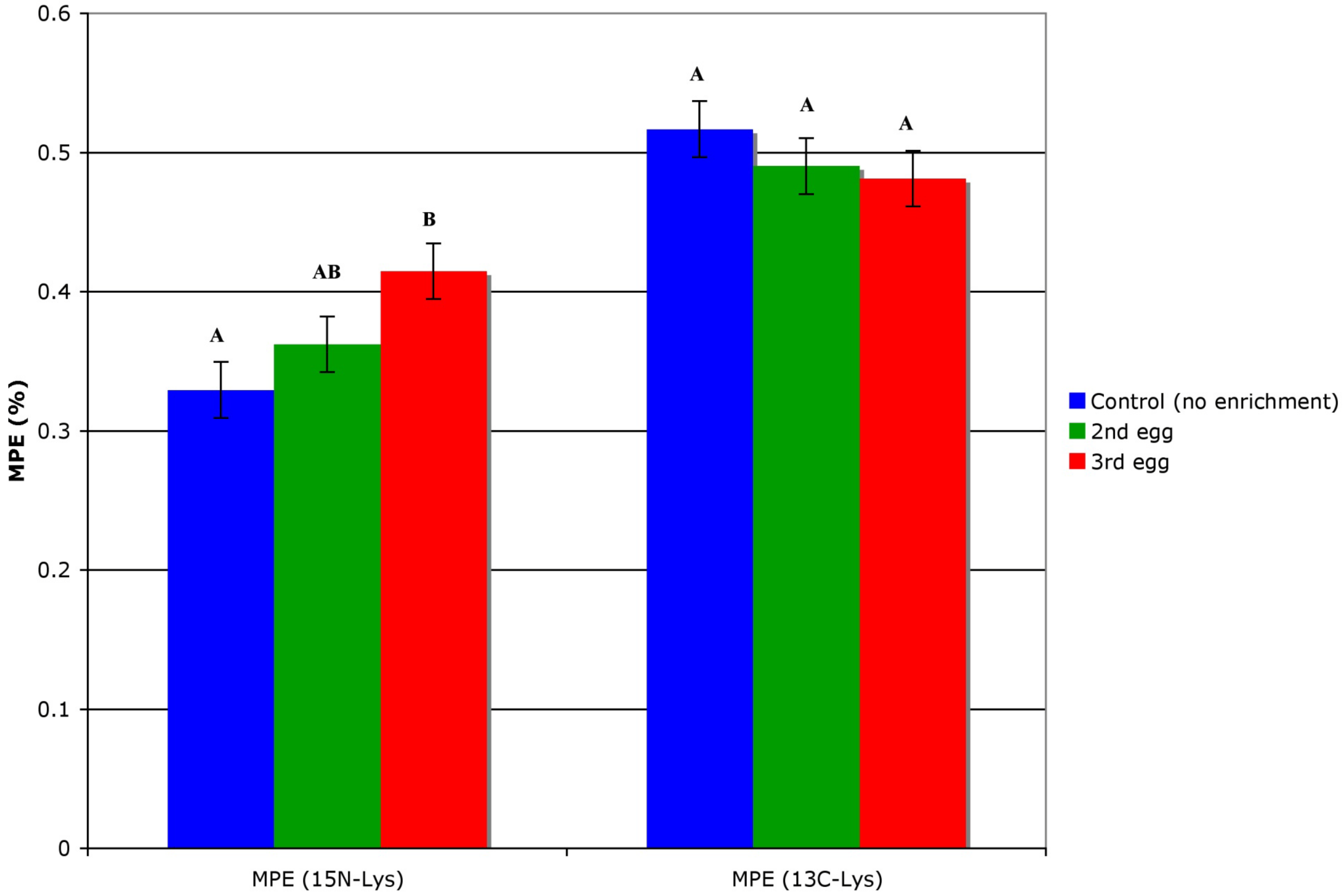
Note: no significant difference in the # of days of ^{15}N enrichment ($P<0.05$)

Breast muscle



^{13}C enrichment
2nd egg- 1.2 d
3rd egg- 3.8 d

Eggs


0.6
0.5
0.4
0.3
0.2
0.1
0
MPE (%)
A
AB
B
A
A
A
MPE (15N-Lys)
MPE (13C-Lys)
Control (no enrichment)
2nd egg
3rd egg

Conclusions

- The increase in ^{15}N-lysine in the egg suggests that breast muscle may be a major source of amino acids for egg formation
- The role of dietary amino acids in egg formation may be limited during the transition into sexual maturity

Applications

- Changes in strains, body weight and composition, egg production, egg size and composition and environmental temperature can be accounted for using a ME Requirement model

- Accurate amino acid requirements can be determined for breeders of any strain or size and in any stage of production

- Nutritional effects on fertility need to be examined and understood

- Don’t overfeed protein in hot temperatures

Acknowledgments

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